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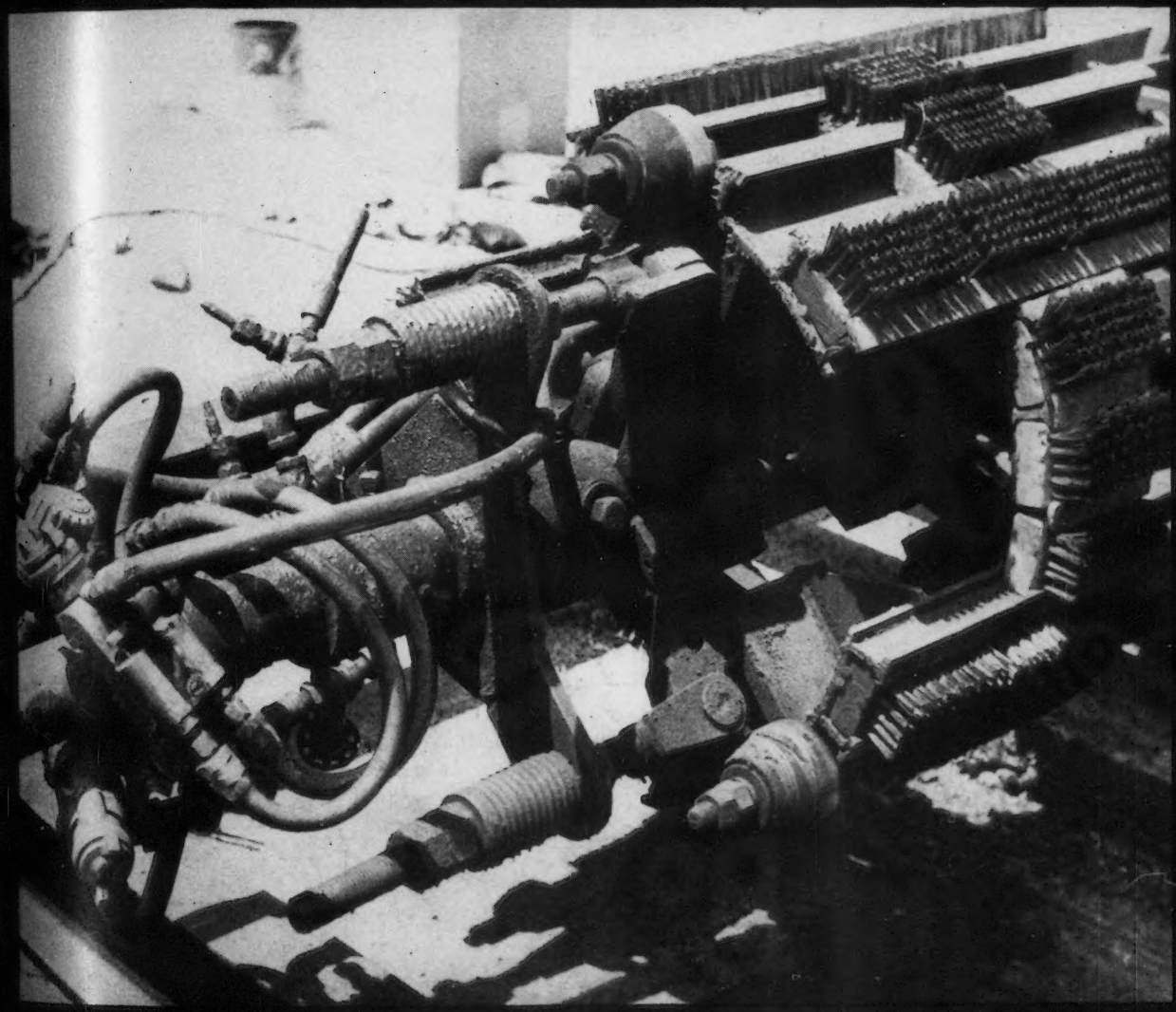

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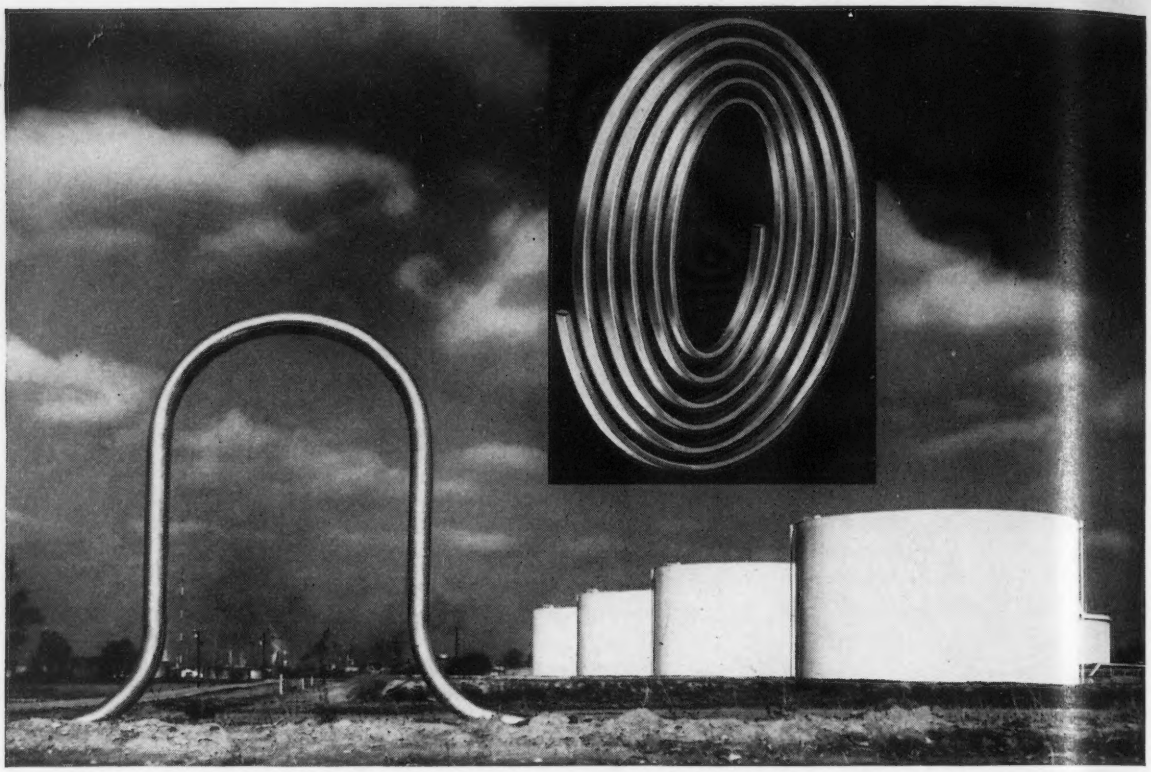

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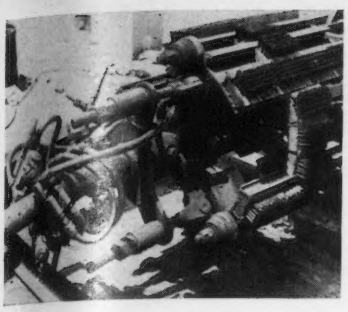

THIS MONTH'S COVER—The cleaning and spraying head of the recently developed Crutcher-Rolfs-Cummings, Inc., internal pipe cleaning and coating device is shown. Compressed air jets blow corrosion products from the pipe as the rotating head withdraws and at the same time sprays the interior. An epon coating formulated by Coast Paint & Lacquer Company was used in initial tests.

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(Continued on Page vi)

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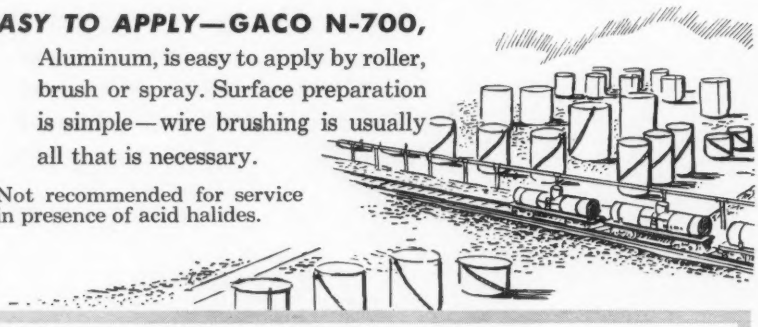

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(Continued From Page v)

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Approximately 7/16 inches high, gold, inlaid with bright red enamel background to "NACE" and deep blue enamel background to words "CORROSION CONTROL." Ruby center.

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Permits high speed wrapping . . . assures effective protection for enamels

TRANSHIELD now offers pipe line men the fine protective qualities of an asbestos shield at a lower price . . . with the added advantage of improved application characteristics. Transhield is a quality felt . . . assuring long trouble-free service. It is designed to meet all ordinary wrapping needs.

Transhield provides a continuous asbestos membrane, protecting and preserving the enamel coating. Highly resistant to soil stress, it is particularly suitable for use where pipe must be laid in heavy clay soils. It cannot rot or decay . . . presents an almost indestructible barrier against soil chemicals.

Contractors like Transhield because its special reinforcement makes it easy to apply, even at high speeds. Embedded continuous glass yarns parallel-spaced on ¼" centers give Transhield unequaled tear resistance. Transhield's light weight permits furnishing it in 800-ft. rolls. This advantage cuts roll changes in half for field wrapping equipment.

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Turn to the Technical Committee News section in this issue for reports on the latest activities of NACE's technical committees. Officers and members of committees are urged to send in for publication information suitable for this section. Copy deadline is the first of the month preceding the month of issue.

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SOMASTIC Coated Pipe will give you that confidence. The pipe coating identified by the registered trade-mark SOMASTIC, is a dense mixture of asphalt-mastic...applied as a continuous, uniform, seamless protective sheath. Desired mechanical strength and other physical properties for each project are secured by properly grading inert materials, and combining them with the optimum amount of the correct grade of asphalt. Waterproofing is assured. The completed, coated pipe withstands stockpiling, field hauling and handling methods that will rupture or distort other coatings.

As to permanence in the ground... our knowledge of the useful life of SOMASTIC Coated Pipe still is limited only by the total time it has been in existence . . . and it has been on the market since 1934.

So . . . why not check on SOMASTIC Pipe Coating the next time you need corrosion protection in *your* pipe line?

PERFORMANCE PROOF AVAILABLE!

Read these typical highlights...

Examination of longest and oldest continuous mastic application to a product pipe line in the Mid-Continent area . . . after 9 years of service. *(Extracted from "Examination of 335 Miles of Asphalt Mastic Coated Pipe," by Donald E. Miltner, published in July, 1953 Corrosion, publication of the National Association of Corrosion Engineers.)*

"The 335 miles of 6⅝ inch OD pipe line extends from Topeka, Kansas, to Sioux Falls, South Dakota. A lightweight pipe of 14.96 pounds per foot was used in this construction because the line was to be coated in its entirety and in addition maintained under cathodic protection. This weight of pipe was selected to allow an adequate factor of safety for the normal range of operating pressures and yet provide for maximum economy in overall investment costs. Five cathodic protection rectifier units were installed soon after construction of the line was completed.

"The three principal methods used to examine the nine year old coating were:

1. A modified Pearson coating discontinuity survey.
2. Inspection of a representative number of indicated coating failures.
3. Coating conductance measurements on isolated sections of the gross structure.

Results. "This survey indicates that the inspection made of the coating during manufacture and construction of the line was of a high order.

"The rate of discontinuities was found to be one per four miles of pipe line. This exceedingly low rate substantiates the high quality of the coating found in the examination.

"The coating was almost completely unaffected by soil stress with the whitewash largely intact.

"The low discontinuity rate per mile and small area of affected coating shows that moderate protective voltages have not affected the sound coating for at least nine years.

"The total area of coating adversely affected from any cause whatsoever was approximately 50 square feet in over 3 million square feet of pipe coating."

Conclusion (ours!) 50 square feet of coating adversely affected out of 3 million square feet after nine years is a *remarkable* record!

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If you wish, we will also send you other field test reports and a list of SOMASTIC Pipe Coating user references near you. We are at your service!

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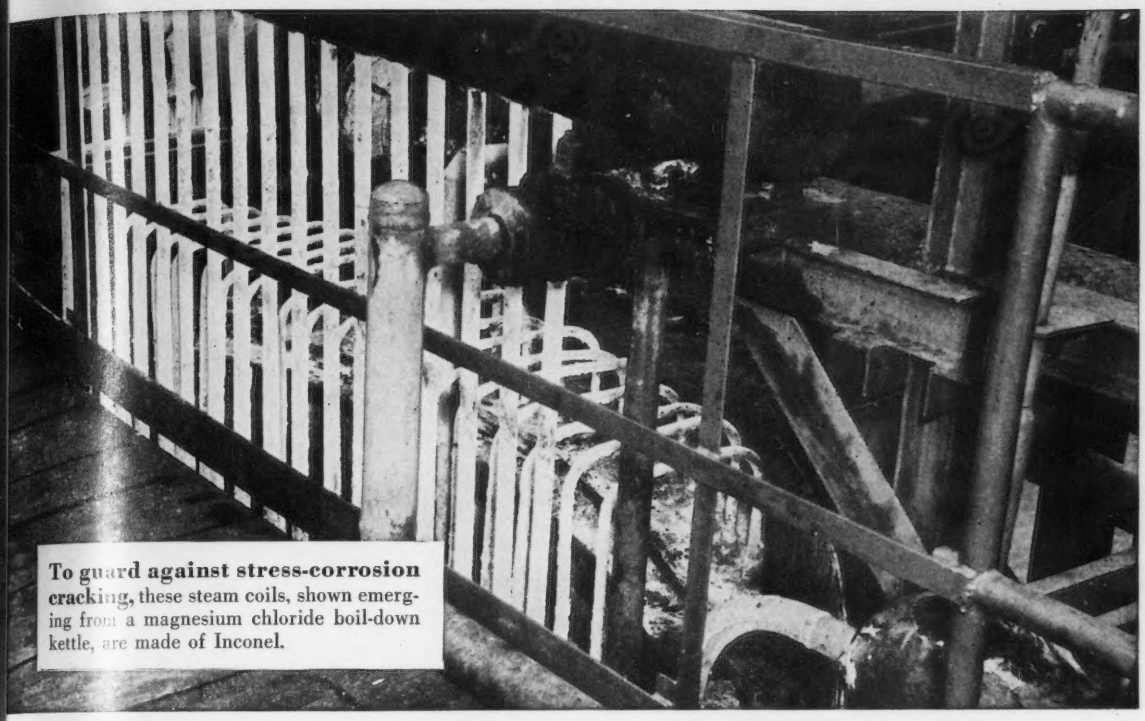

To guard against stress-corrosion cracking, these steam coils, shown emerging from a magnesium chloride boil-down kettle, are made of Inconel.

HANDLING CHLORIDES?

Here's how Inco Nickel Alloys are being used today to protect equipment against chloride corrosion.

Take the magnesium chloride concentration operation shown here, for example.

Those steam coils have to withstand general attack by the hot, highly corrosive 34% to 48% solution. Even more important, they must successfully resist stress-corrosion cracking, which is enthusiastically promoted by magnesium chloride.

Inconel does the job. In magnesium chloride solutions, Inconel shows no tendency toward stress-corrosion cracking and its corrosion rate is usually on the order of only 0.001 in. per year or less.

What about alkaline or neutral salts such as sodium or calcium chloride? Monel is commonly used for major items of refining equipment . . . even in rotary driers where temperatures go up to 350° F. Where solid salt contacts metal surfaces for extended periods . . . or where absolute freedom from copper is desired, Inco Nickel is usually employed.

In acid salts, such as zinc chloride or ammonium chloride, the Inco Nickel Alloys also exhibit valuable corrosion-resistance. Nickel and Monel have a corrosion rate of the order of only 0.02 in. per year in the boiling concentrated solutions and are therefore used in evaporator equipment.

In the manufacture and transportation of phosphorus oxychloride and trichloride and of nitrosyl, benzyl, acetyl, and benzoyl chlorides, Nickel is widely used. After twelve years use in separating chlorine from nitrosyl chloride, a Nickel rectification tower showed no appreciable corrosion.

If you have a corrosion problem involving the handling of chlorides, write to Inco's Corrosion Engineering Section. They will be glad to help you without cost or obligation.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

Inco Nickel Alloys

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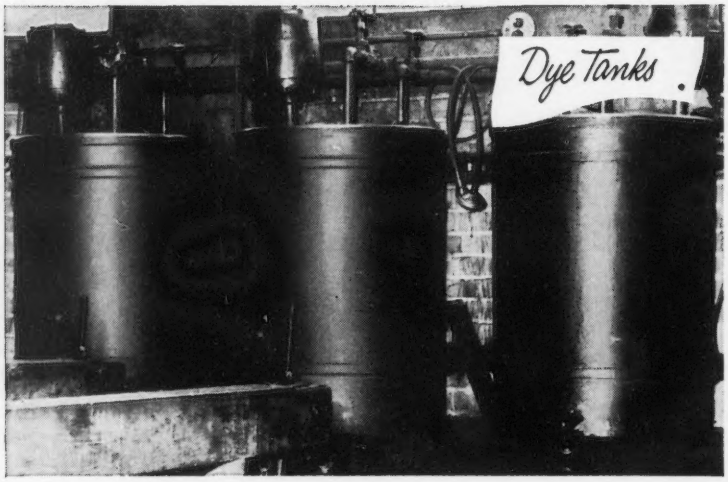


-they stop corrosion caused by

INDUSTRIAL ATMOSPHERES

HEAT

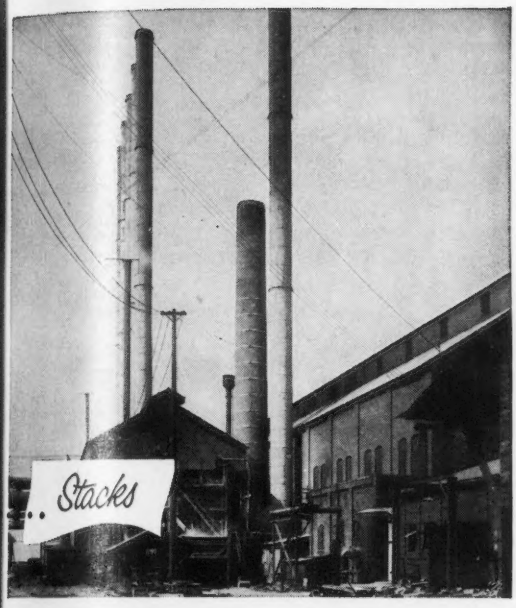
ACID FUMES

MOISTURE

SALT AIR

CORROSIVE SOIL

problems by using Bitumastic® Coatings



Now starting their second Century of Service

BITUMASTIC PROTECTION
100TH Anniversary
1854 1954

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Corrosion

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An Association of Individuals and Organizations Concerned with Control of Corrosion

1061 M & M Building Houston 2, Texas

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Topic of the Month

Figure 1—Spike as received. Approx. X3.

Examination of an Old Bronze Ship Spike Taken from a Wreck at Nags Head, N. C.

By A. W. TRACY*

Abstract

Comparisons of microstructure of a bronze spike taken from a wrecked ship at Nags Point, N. C. with that of spikes from the frigate Constitution and nails taken from Boston's Old South Church roof fastening copper sheets dated 1838 establishes the age of the craft as the last half of the eighteenth or first half of the nineteenth century.

ON APRIL 27, 1951, a bronze spike was removed from an old shipwreck at Nags Head, North Carolina. Among the interested parties considerable discussion developed as to the possible age of the wreck and if there was any metallurgical or chemical way by which the age and the alloy could be determined.

The attached photograph, Figure 1 (Magnification X3) shows the appearance of this spike as received. Unfortunately, this black and white photograph does not give a true picture of the green colored corrosion products adhering particularly to the head of this spike. The spike weighed 52.60 grams as received.

Chemical and spectrographic analyses showed the following:

Copper	88.24%
Tin	2.24
Lead	2.41
Iron	.4
Aluminum	.00
Nickel	.04
Arsenic	.10
Silver	.03
Antimony	.05
Bismuth	.10
Phosphorus	.006
Zinc	6.38

* American Brass Company, Waterbury, Conn.

The relatively high concentration of such elements as iron, nickel, arsenic, silver, antimony and bismuth is typical of the bronzes of the period preceding the advent of modern refining methods.

Microscopic examination showed a typical cast dendritic microstructure. No evidence of cold working could be found in the body of the spike. Some evidence of cold working (slip-lines) was found in the head of the spike, evidently due to the hammer blows used to drive the spike into place. Figure 2 (magnification X75) is a photomicrograph of a cross-section of this spike showing the cast dendritic structure.

A comparison was made of the photomicrographs obtained from this spike and from a spike taken from the well-known "Constitution" of the Revolutionary War days. This comparison showed that the microstructure of both of these spikes was practically identical. In addition, the microstructure was found to be identical to that found in large bronze nails taken from the Old South Church in Boston where the underside of the copper roofing held in place by these nails was dated 1838.

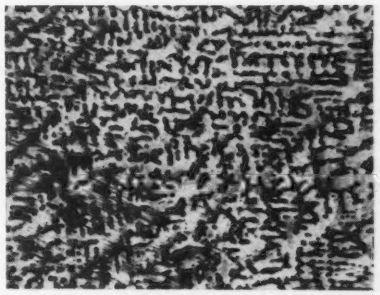

Figure 2—Photomicrograph showing dendritic cast microstructure of bronze spike. X 75.

The composition and cast microstructure of this spike fits the period shortly before the Civil War or, more broadly, the period starting with the 18th Century and the first half of the 19th Century. A search of old historical records showed that a number of ships constructed in the 18th Century or the first half of the 19th Century found their final resting place along the Carolina Coast. At this time there still is speculation regarding the name of this old sailing vessel and the type of molds used to cast the large number of spikes needed in such construction.

Performance of these bronze spikes in sea water clearly shows how copper alloys developed their good reputation and why these materials are so widely preferred as fastenings, etc. for marine services. Modern practice, however, is to use the wrought alloys since most of them are stronger and are just as corrosion-resistant as the older casting alloys.

Comparisons of Cathodic Protection Test Methods*

By KIRK H. LOGAN

I. Introduction

CATHODIC protection engineers have developed several methods for determining when a pipe line has become protected by the application of current to the line. This paper is an account of trials of four of these methods on pipes buried in soils having a wide range of resistivities and other characteristics. While differences in the results could have been predicted qualitatively before the tests were made, nevertheless their magnitude may be of interest to those who have wondered whether the different methods produced significantly different results. Some observations on polarization phenomena and test apparatus have been added for the benefit of those just beginning cathodic protection work.

II. Methods and Instruments

In general, the tests consisted in applying increments of current to a pipe and observing the change in its potential. The anode by which the current entered the ground was from 25 to 100 feet from the pipe. Some of the pipes were uncoated where others had been dipped in hot coal tar or sprayed with a coal tar cut-back.

Because the points on the graphs to be presented frequently do not fall exactly on a smooth curve, the question may arise as to whether the deviations are the results of instrument and observation errors or are the results of polarization phenomena. A brief description of the instruments used is therefore in order.

The instruments used were copper-copper sulfate reference electrodes, multiple range Weston and General Electric Company milliammeters, Model I Weston multiple range low resistance voltmeters and a Susquehanna Model I Vacuum tube voltmeter[1] used as a voltmeter or as a null galvanometer in a backing out circuit.

The reference electrodes were two inches in diameter and differed in potential by 3 to 6 millivolts. When placed end to end, their joint resistance was 90 ohms, part of which was due to imperfect contact between the wooden plugs.

The voltmeters were accurate to ¼ of 1 percent of full scale deflection, i.e. to ¼ of a scale division. Observations were made to 0.1 of a division. The milliammeters had an original accuracy of ½ percent of full scale deflection and currents were so chosen that the pointer of the ammeter rested on a division line.

With one exception the potentials in the tests, which included IR drop, were made with a Susquehanna, or a PH meter vacuum tube voltmeter having a very high resistance.

★ A paper delivered at the Ninth Annual Conference, National Association of Corrosion Engineers, Chicago, Ill., March 16-20, 1953.

KIRK H. LOGAN—For more than 30 years Mr. Logan has been occupied with problems related to the underground corrosion of metals. For many years he was Chief, Underground Corrosion Section, National Bureau of Standards. He is now research engineer with Cast Iron Pipe Research Association. He received the 1951 NACE Speller award, is a Fellow and life member of AIEE, a member of NACE since its organization and a member of numerous other technical groups. His papers on underground corrosion are numerous.

Abstract

This paper compares the results of cathodic potential tests including and excluding IR drop and with the reference electrode both over and remote from the pipe.

Results of using the break in the current potential curve as a criterion for protection are compared with lowering the pipe potential —0.3 volt and to —0.85 volt. The criteria do not agree.

Results of increasing the test current in equal steps are compared with those obtained by increasing the current by 50 percent increments. Equal current increments give smoother curves.

The necessity for equally spaced times of potential observations is discussed. This is desirable but not always necessary.

Data plotted on rectangular coordinate paper are compared with the same data plotted on semilog paper. Sometimes it is best to use both methods.

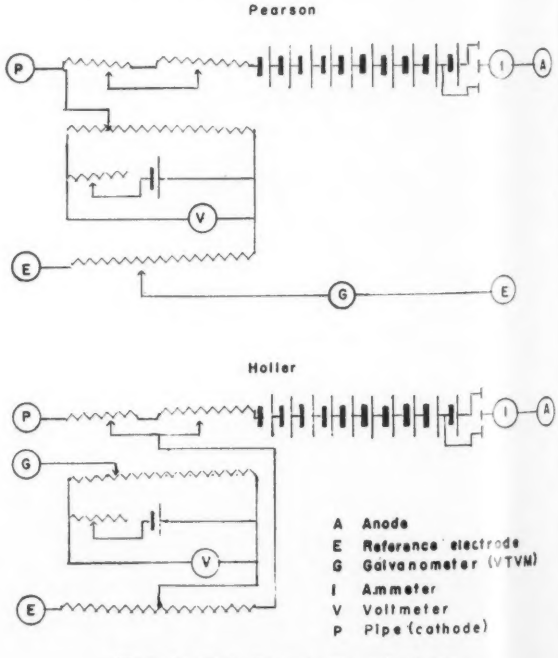

Figure 1—Cathodic protection null circuits.

The potentials in the null tests, the circuits of which are shown schematically in Figure 1 were determined by backing out the deflection of a vacuum tube voltmeter having a full scale deflection of 0.1 volt. The backing out circuit used was shown to the writer by H. D. Holler. Instead of reading the backing out voltage directly as is done with a potentiometer-voltmeter, a potential of exactly 1 volt (or 0.5 volt) is connected across a graduated 1000-ohm potentiometer (Helipot) having 1000 divisions (i.e. one division equals one millivolt). Its linearity is accurate to 0.5 percent. This is equivalent to a voltmeter having 1000 divisions and a full scale deflection of 1 volt. On the other hand, any variation in the potential impressed across the potentiometer and any inaccuracy of the voltmeter indicating this potential is reflected in the observations.

Both the Pearson and the Holler null circuits are Wheatstone bridge circuits. The Pearson circuit uses two metallic variable arms, the sum of their resistances in the apparatus used being 200,000 ohms. The other two bridge arms are soil resistances terminating in copper-copper sulfate electrodes. The Holler circuit uses two equal fixed, 100,000-ohm resistance arms, one soil resistance arm and one variable resistance which carries all current used to polarize the pipe. In the high resistance soil test the used part of the variable arm had a resistance of about 6 ohms; for one of the low resistance soils all of the variable resistance was cut out leaving only the resistance of the wire between the battery and the pipe.

When the soil resistance is high the Pearson bridge can be adjusted accurately. If the soil resistance is very low the Pearson bridge is insensitive. Both circuits work well in soils having resistivities of at least several hundred ohm centimeters if small test currents are employed. The Pearson circuit can be used with currents of a hundred amperes or more. The theory and use of both circuits have been discussed elsewhere.[2,3]

The work discussed in this paper consists in applying increments of current to sections of pipe 7 inches in outside diameter and from 80 to 120 feet long and observing the resulting change in the potential of the pipe with respect to copper-copper sulfate electrodes in various positions with respect to the pipe.

The problems to be discussed are:

1. The effect of the location of the reference electrode.
2. The importance of the IR drop which may be included in the potential measurements.
3. The importance of the time and quantity interval of the current increments.
4. The way the data should be plotted.
5. The significance of the data with respect to the current or potential required for cathodic protection.

III. Presentation of Data

A. Effect of Reference Electrode Location

There are two schools of thought regarding the proper location of the electrode to which the potential of the pipe is referred. Some engineers prefer to place the electrode on the surface of the ground over the pipe. Another group places the electrode remote from the pipe at a point where the earth will not be affected

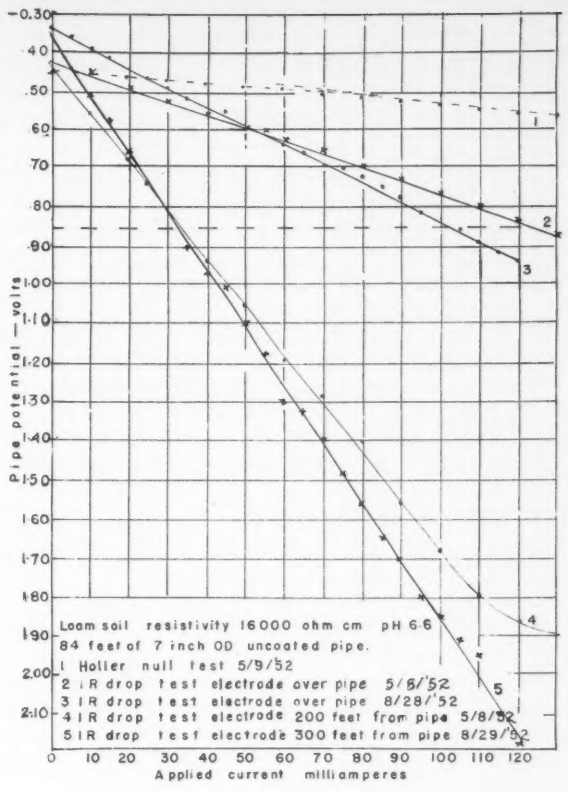

Figure 2—Current-potential curves. High resistivity soil.

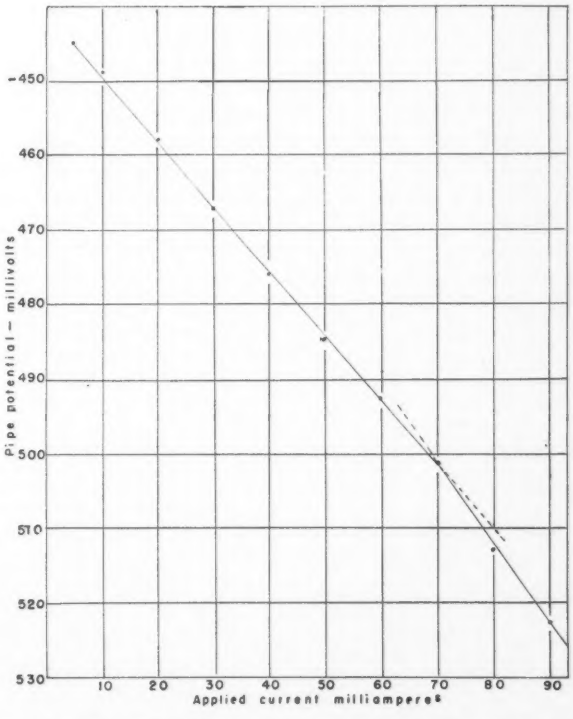

Figure 3—Cathodic protection curve. High resistivity acid soil. Enlarged Curve 1 from Figure 2.

by the current flowing from the anode to the pipe. A third group prefer to compensate for the IR drop in the soil and thus measure the real change in potential of the pipe with respect to the adjacent soil. The choice of methods may depend on the effectiveness of the pipe coating, if any.

Pearson[4] has shown that the length of pipe affecting a reference electrode is roughly four times the distance between the electrode and the pipe. This being the case, the electrode over the pipe 3 feet deep observes the average potential of roughly twelve feet of pipe while the electrode 200 feet away observes the average potential of 800 feet of pipe. Whether these averages would be the same depends on the uniformity of the soil and the distribution of the corroding areas. Neither observation registers the potential at the point which is corroding unless or until the observed pipe has an equal potential surface.

B. Tests in High Resistance Soil

Figure 2 shows the results of tests in a well drained soil which is a mixture of shale and loam. Its resistivity varies between 10,000 and 17,000 ohm centimeters. The potential of the pipe referred to a copper-copper sulfate electrode ranges between — .350 volt and — .680 volt depending on the season of the year. In this test one electrode was placed over the pipe which had about 24 inches of cover while another electrode was placed 200 or 300 feet from the pipe on the side opposite the anode.

The pipe was 84 feet long and had an outside diameter of 7 inches, giving it an area of approximately 143 square feet. The pipe was uncoated. Two sets of tests were run, one in May and the other in the following August after a long dry period. The data do not fall exactly on a straight line possibly because of instrument and observation errors but they are sufficient in number to define the trend of the data. Schwerdtfeger[5] found that under the conditions of his test current-potential curves showed a break or change in direction when the pipe becomes polarized.

Curve No. 1 in Figure 2 shows a slight change in direction at about 70 milliamperes. This break is much more evident when the data are plotted using a more favorable potential ordinate as in Figure 3. The curve was obtained with the Holler null circuit. Curves 2 through 5 include IR drop. The reference electrode for these tests was over the pipe in 2 and 3. Curves 4 and 5 show the effect of placing the electrode a few hundred feet from the pipe. Curves 1, 2, and 4 were taken when the soil was wet, the other curves were obtained during a very dry season.

The high initial potential of the pipe, between — 0.35 and — 0.45 volt, is of interest as is the fact that the electrode over the pipe and the remote electrode showed practically the same initial pipe-to-soil potential although this differed at different seasons. The character of the soil and its high resistivity suggests it is not corrosive.

One must conclude that under the conditions of this test, the current-potential data which include IR drop give no indication as to the current or potential required to protect the pipe.

This is because in high resistivity soil the IR drop is so great that it obscures the polarization effect.

Figure 2 shows the pipe to be 0.85 volt negative when the IR test electrode is over the pipe and the null test shows the pipe potential to be about 0.55 volt, i.e. the IR drop in the soil is about 0.3 volt. When the remote electrode showed the pipe potential to be — .0.85 volt, the null test showed it to be only — 0.454 volt.

In this noncorrosive soil, the pipe potential had to be lowered 0.4 volt or more to bring its potential to — 0.85 volt if IR drop was included; whereas the null test indicates that a change of only 40 millivolts is necessary for protection. The writer is not in a position to say which of the three criteria—curve break, a change in pipe potential of 0.3 volt, or a pipe potential of —0.85 volt—is the correct criterion for protection. It is evident that the disagreement should be investigated.

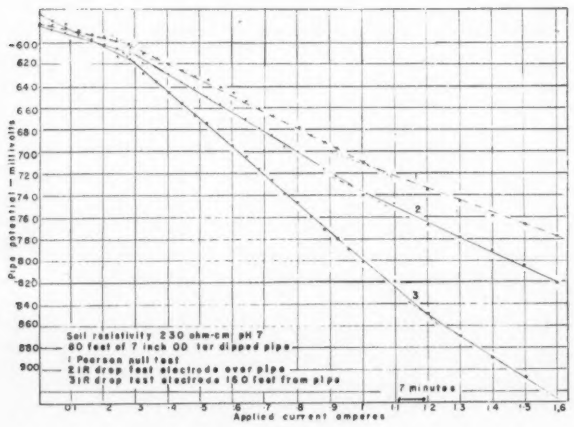

Figure 4—Cathodic protection curves. Low resistivity, neutral soil. January 16, 1951.

C. Tests In Low Resistance Soil

Figure 4 shows the results of tests in a neutral low resistance soil consisting of a mixture of sand and muck.

The pipe involved was 80 feet of tar-dipped, 7-inch OD pipe. Curve 1 shows the data for a Pearson null test. Curve 2 includes IR drop. The reference electrode was over the pipe. Curve 3 shows the result of placing the reference electrode 160 feet from the pipe.

All curves show breaks at a current of about 0.26-ampere which according to Schwerdtfeger[5] is the protective current. The initial potential of the pipe for this current is about — 0.6 volt but this decreases as the time of current application is increased.

The soil at the test site is very corrosive but the coating is new and it is impossible to determine the area of the metal actually exposed to the soil. A second change in the direction of the curves occurs at a current of one ampere for the two upper curves and at 1.2 ampere for the remote electrode curve. The potential at which the lowest curves breaks is — 0.85 volt. The corresponding null potential was — 0.73 volt.

Two other items of interest are shown in Figure 4. With the exception of one time, the observations were made at 3-minute intervals. The current increment was 40 milliamperes until a total current of one ampere was reached when the increment was increased to 100 milliamperes. No change in the shape of the curves occurred when the current increment was changed.

Because of an accident between the application of 1.1 amperes and the application of 1.2 amperes, 7 minutes elapsed. This did not affect the slopes of the curves. Probably this is because in this soil the major part of the polarization occurs within 2 minutes. However, tests have shown that with a steady current the potential of the pipe falls slowly for several days. Under some conditions it is quite important to make observations at equally spaced time intervals. Schwerdtfeger recommends that uniform current increments be used. Pearson says that each increment should be from 25 to 50 percent greater than the preceding one. Apparently in such soils as represented in Figure 4, it is not necessary to eliminate the IR drop to obtain breaks in current-potential curves and the reference electrode may be either over the pipe or remote.

Figure 5 shows curves obtained in a wet alkali soil having a resistivity of about 90 ohm centimeters. The initial potential of the pipe was about 0.76 volt. The cathode was 108 feet of new 7-inch OD tar-coated pipe. The pipe was laid three days before the test.

Curve 1 represents Pearson null method data. Curve 2 was an IR drop test with a lead chloride reference electrode over the pipe and a PH meter which showed only changes in potential to plot the curves. It was assumed that the original potential was that indicated by the Pearson test.

Curves 1 and 2 were obtained simultaneously. Curves 3 and 4 were also taken simultaneously about five hours before Curves 1 and 2. Curve 3 shows the results of the Holler test. Curve 4 is an IR drop test with the electrode 20 feet from the pipe.

The Pearson and Holler curves 1 and 3 show the first breaks at the same current, 43 milliamperes, though the pipe potentials differed by about 14 millivolts. Each curve also shows a second break but not at the same current or potential. The first part of the lead chloride Curve 2 exhibits a gradual change in slope but becomes a straight line at about the same current that caused a break in the IR drop Curve 4 which, like Curves 1 and 3 shows a second break. Figure 4 and Figure 5 indicate that breaks in current-potential curves can be obtained without eliminating the IR drop if soil resistivity is low. Possibly the explanation of the greater current required to obtain a break in the curve when the electrode is remote, is that the remote electrode views more pipe. It has been suggested that the second break in the curves is the hydrogen overvoltage point. Apparently little work has been done to explain this break. Under some conditions when the current has been greatly increased, the curve becomes very erratic and may turn up or down. This erratic behavior may be the result of an unbalanced bridge. Apparently, the soil

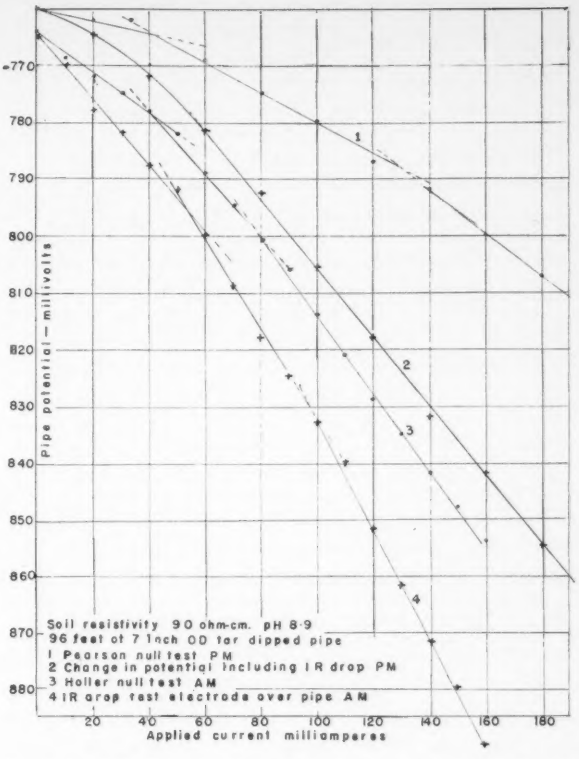

Figure 5—Cathodic protection curves. Low resistivity alkali soil. July 6, 1952.

resistivity changes with the passage of current through it.

IV. Methods for Plotting Current Potential Curves

To those who use current-potential curves, the choice of methods for plotting these curves is of interest. Schwerdtfeger uses linear rectangular coordinate paper and equal time and current increments. Because polarization is supposed to be a logarithmic function of the current some prefer to plot the curves on semi-log paper and for such curves an increasing current increment gives better spaced points on the curve and shortens the time required for the test.

In Figure 6, Curve 1 is plotted from data taken two days later at the same test site that furnished the data for Curve 1, Figure 2, using 50 percent current increment steps. No part of the line is straight and there is no indication of a critical current.

Curve 2 was obtained with the Holler null circuit and current increments of 10 milliamperes. The lower part of the line is straight or very nearly so and a Schwerdtfeger critical current is indicated at 76 milliamperes. This checks fairly well with the critical current 71 milliamperes in Figure 3 plotted from the same data. Curve 3, Figure 6 represents the same data as Curve 2, Figure 2 and shows no critical current.

Comparisons of the curves in Figures 2 and 6 indicate that the semilog paper shows the critical current a little more plainly than the linear rectangular coordinate paper. The use of equal current increments seems preferable to increases of 50 percent.

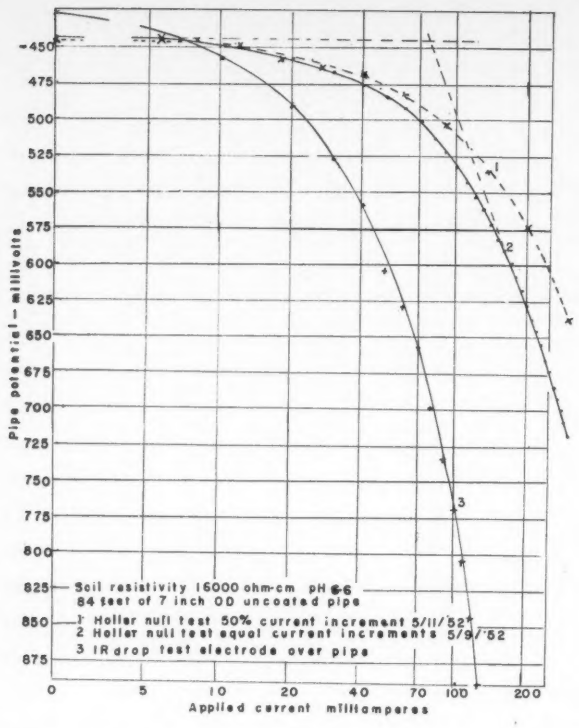
Pipe potential — millivolts
Applied current milliamperes
Soil resistivity 16000 ohm-cm pH 6.6
84 feet of 7 inch OD uncoated pipe
1 Holler null test 50% current increment 5/11/52
2 Holler null test equal current increments 5/9/52
3 IR drop test electrode over pipe

Figure 6—Cathodic protection curves. High resistivity acid soil. Same site as Figure 2.

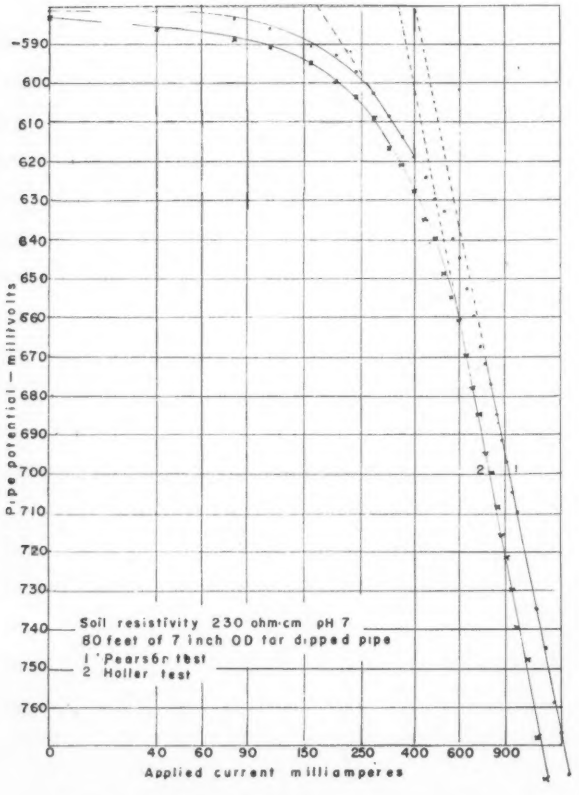
Pipe potential — millivolts
Applied current milliamperes
Soil resistivity 230 ohm-cm pH 7
80 feet of 7 inch OD tar dipped pipe
1 Pearson test
2 Holler test

Figure 7—Cathodic protection curves. Low resistivity soil.

Possibly a 25 percent increment would be a good compromise since it would save time and Figure 4 indicates that if the time interval is sufficient increasing the current increment does not change the shape of the curve.

Figure 7 shows the use of semi-log paper for plotting data from a low resistance soil. The data are the same as those shown in Curves 1 and 2 of Figure 4. At the breaks in neither figure do the data fall exactly on a smooth curve but the departures are, with a few exceptions, no greater than inaccuracies of the instruments. It is probably impractical to attempt to make more precise field observations.

V. Conclusions

In the three soil types discussed in this paper it is possible to get a distinct break in current-potential curves if the IR drop is eliminated.

Similar results have been obtained by the writer at several other test sites covering a wide variety of soils. Except in very high resistivity soil breaks in current potential curves have been obtained without eliminating the IR drop though in most cases the breaks are not quite so well defined.

The indicated protective currents and potentials are different for the three test methods, i.e., breaks in current potential curves, 0.3 volt lowering of the pipe potential and lowering of pipe potention to — 0.85 volt.

When the IR drop is included in the pipe potential, the current required to lower the pipe to — 0.85 volt depends on the distance between the reference electrode and the pipe.

When no current is applied to the pipe, the potential of the pipe with respect to a reference electrode over the pipe may or may not be the same as that referred to a remote electrode.

It is doubtful whether a null method is justified. The possible errors which may result from the multiplicity of batteries, instruments and adjustments involved tend to nullify the advantage of the elimination of the IR drop.

It appears that under some conditions protection is attained before the pipe potential is lowered to — 0.85 volt with respect to a copper sulfate electrode and it is possible that the break in the current potential curve is a better criterion for protection.

It does not seem important whether equal or unequal current incrmeents are used. Either rectangular or semi-log coordinate paper for plotting data will give satisfactory results if sufficient data are taken. Both kinds of paper may be plotted if one gives inconclusive indications.

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DISCUSSION

Discussion by Irving A. Denison, Diamond Ordnance Fuze Laboratories, Washington, D. C.:

The significant feature of the data reported by Mr. Logan is that they indicate that the minimum current density initially required for the cathodic protection of pipe lines can be measured simply with a high-resistance voltmeter and a reference electrode, that is, no special circuit for the elimination of IR drop is required. The limitation of the simplified method is that the IR drop included in the voltmeter reading will tend to obscure the break in the current-potential curve if the soil resistivity is high as is shown, by the curves for the high resistivity soil in Figure 2.

The protective current of about 275 ma indicated by the breaks in the curves for the neutral, low-resistivity soil (Figure 4) would probably be sufficient to eliminate practically all of the local corrosion circuits because at this current the pipe is polarized to the average open-circuit potential of the anode areas. Any residual corrosion resulting from more anodic potentials would be eliminated by the gradual drift in the potential of the pipe in the anodic direction. Under most conditions continuous application of the current indicated by the break will cause the potential to drift to the protective potential of about —0.85 volt.

The current of 1.2 amperes corresponding to a potential of —0.85 v in Curve 3 of Figure 4, for example, has no significance as regards the current *initially* REQUIRED for cathodic protection.

With regard to the method of plotting, the protective current of 70 ma required for the protection of the pipe in the high resistance soil is indicated more exactly by the curves plotted on rectangular coordinates Figures 2 and 3 (Curve 1) than by those or semi-log coordinates (Figure 6, Curve 2) in spite of the greater changes in slope indicated by the latter. However, the log plot will usually reveal the location of the break that is significant for cathodic protection.

Discussion by Frank Kahn, Philadelphia Electric Company, Philadelphia, Pa.

The simplicity and convenience of field measurements of IR-drop structure-to-soil potentials with the copper-sulfate electrode are responsible for its popularity for use in estimating current requirements for cathodic protection of steel structures. However, there is little help in the technical literature concerning the appropriate criteria for determining when protection is achieved; whether the electrode should be placed at remote earth or directly over the structure and whether the structure potential should be lowered 0.3 volt or maintained at —0.85 volt.

Howell[1] positions the electrode directly over the line and has found a potential change of 0.3 volt to be adequate, but suspects that it may result in considerable overprotection. Collins and Thalmann[2] advocate using the criterion of —0.85 volt with respect to a remote electrode, when shielding and proximity effects are small. Van Nouhuys[3] has lowered pipe-to-soil potential of 350 miles of pipe a minimum of 0.3 volt to a remote electrode but does not claim that every local concentration cell leak is thereby prevented.

Mr. Logan has presented data, particularly in Figures 2 and 3, which appear to be helpful for the case of well-drained high-resistance soils having an initial potential of the order of —0.4 volt. Potentials of this order are anomalous in that they cannot be accounted for by anodic polarization of iron and are frequently met with in soils of the Greater Philadelphia Area.

In Curve 1 of Figure 2 (shown enlarged in Figure 3) the break in the current potential curve for the Holler null test occurs at 70 milliamperes, the Schwerdtfeger criterion of protection. In the over-the-pipe-electrode IR-drop tests of Curve 2, the current corresponding to a drop of 0.3 volt from the initial potential of the average curve is 86 milliamperes, or 23 percent in excess of the Schwerdtfeger criterion. The current requirement for a pipe potential of —0.85 volt from Curve 2, however, is 123 milliamperes, an excess of 75 percent over the Schwerdtfeger criterion.

Referring to Curve 4 for IR-drop tests with remote electrode, a current of 25 milliamperes is required for a drop of 0.3 volt from the initial potential and a current of 34 millliamperes for a pipe potential of —0.85 volt. These values are respectively of the order of ⅓ and ½ the 70-milliampere current requirement indicated by the Schwerdtfeger criterion. It is to be noted that the data for Curves 1, 2 and 4 were taken within a period of two days.

For the tests of Figure 2, the current requirement for a 0.3-volt change in average over-the-pipe potential is in much the closest accord with and somewhat in excess of that indicated by the Schwerdtfeger criterion.

It would thus appear that the 0.3-volt drop in over-the-pipe potential may prove an acceptable and convenient method of approximating the Schwerdtfeger criterion for a well-drained high-resistance soil having initial potentials of the order of —0.4 volt.

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Some Early Patents on Cathodic Protection*

By ROBERT POPE*

THERE are, of course, many patents on methods of preventing corrosion. Years ago, the principal cause of corrosion of underground metallic structures was the effect of stray d-c current from electric traction systems and, therefore, most of the earliest patents had to do with methods of operating the traction system to minimize stray currents or with interconnections between the underground structures and the traction system.

Patent No. 538,758 was issued to R. Watkins on May 7, 1895. It is entitled, "Preventing Electrolysis of Street Pipes." It is described as, "a method of preventing electrolysis of metal street pipes located adjacent to electric railways, which consists of connecting the pipes to the return conductor or the generator, whereby the said pipes receive and conduct the surplus electricity, which would otherwise indirectly charge the earth adjacent to or surrounding the pipes, thereby preventing electrolytic action." This apparently covered the drainage wire type of cathodic protection which became universally used wherever trolleys were operated. Watkins should have made a fortune from it.

On June 25, 1895, H. P. Brown obtained Patent No. 541,467 covering "Methods of Preventing Electrolysis of Pipes Underground." In explaining the application of the method, the patent states, "When an electric current is passed from one metal terminal to another through a conducting fluid like acidulated water, the fluid is decomposed, the oxygen of the fluid being set free at the outgoing (sic) or positive pole and the hydrogen at the negative pole. The oxygen at once corrodes the metal of the positive pole if capable of oxidation . . ." The reference to "the outgoing or positive pole" may have started the controversy on current direction which persists to this day. The patent covered arrangements of generators to provide a bus of lower potential than the negative bus for the purpose of providing a point for connecting drainage wires from underground structures.

W. Cramer obtained Patent No. 636,638 on November 7, 1899. It covers a "Means for Intercepting Earth Currents in Electrical Traction." The description states "The invention consists in inclosing the track within a continuous shield of good conductive material which is not in conductive connection with the rails and which is connected with the same pole of the dynamo as the rails." Offhand, it would seem that the use of negative feeders would be less expensive and at least as effective as the shield in controlling stray current.

S. Krohn's Patent No. 652,187 dated June 19, 1900 is entitled, "System of Electrical Distribution." It covers the use of positive and negative feeders. At the generating station the feeders are connected to special generators so that the positive feeders are supplied at a higher voltage and the negative feeders at a lower voltage than is supplied to the directly connected trolley wire and rail. This extra voltage overcomes the IR drop in feeders. In the case of the negative feeder, this could create a point of low voltage on the track to which underground structures would discharge current.

A patent, No. 661,165, was issued to L. I. Blake on November 6, 1900, for "Protecting Underground Metallic Structures from Effects of Electrolysis." Broadly, the patent describes, "A conducting coating applied to underground metallic structure, which is unaffected by electrolytic action and impervious to the products of such action." Specifically the patent covers imbedding the structure in a continuous graphite environment.

On April 18, 1911, Hermann Geppert of Karlsruhe, Germany, obtained Patent No. 989,596 covering a "Method of Protecting Articles from Earth Currents." The description states, "The article to be protected is connected to the negative pole of any convenient source of electricity (cells, accumulators, dynamos) while at the same time, anodes sunk into the earth in suitable positions, are connected to the positive pole of the same source of electricity." While the patent was obtained primarily as a protection against the effects of stray currents, it covers cathodic protection by means of sacrificial anodes as widely used where no stray current exists.

In the early 1920's G. G. Jones endeavored to obtain a patent on his "raised earth potential" protection. However, Geppert's claims were so broad that they included Jones' scheme. However, on May 15, 1933 Jones obtained Patent No. 1,454,895 covering an "improved arrangement for raising the earth potential in the vicinity of metallic articles."

There are, of course, hundreds of additional patents covering reverse current switches, boosters, regulators, etc., but the few described above seemed to be of particular interest.

★ The first in a series of six articles on early developments in cathodic protection and corrosion mitigation measures on underground structures.

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Some Experiences With Cathodic Protection in Chicago*

By L. M. PLYM

WHEN the traction companies began using electric power with the current returned to the supply source by means of rails, anodic corrosion caused many failures in underground plant. Eventually it was learned that electrical connections between the plant subject to damage and the negative leads at the power source would prevent these failures. Changes in traction loads caused some power supply stations to be shut down for certain hours of the day so automatic electrolysis switches were introduced to open the electrical connections to prevent current flowing in the reverse direction. An effective cathodic protection system resulted from these activities and subsequent failures due to electrolysis were attributed to switching troubles and plant or operation changes.

It was thought that the underground plant was safe as long as the potential to earth was negative. Then salt appeared as a means of preventing ice formation on the streets and rails. After a few years of leaching through the soil, some of this salt came to rest in the underground cable ducts. Cathodic corrosion reared its ugly head and a new method of attack was developed. An attempt was made to arrange the electrical connections so that the plant was not so highly negative, thus reducing the speed of failure. Efforts to find a substitute for salt were unsuccessful. Grease was applied to repaired cables to keep the salt electrolyte from the cable sheath. Special corrosion protecting tape coverings were also used and finally polyethylene sheathing appeared. Polyethylene appears to be the answer to most of the problems encountered. However, the Chicago area of Illinois Bell Telephone Company still has about 4000 miles of lead sheathed cables which must be protected.

The Chicago Transit Authority, in its efforts to reduce costs and improve efficiency, has eliminated some cross-city car lines and is operating its substations on new schedules. These changes result in the loss of cathodic protection in some areas. Anodic conditions as well as local action effects may develop due to differences in metals or soils. To prevent these effects, it appears necessary to substitute new cathodic protection systems. By using insulating joints to isolate cable sections, miles of cable sheath

L. M. PLYM—He has been Electrical Coordination Engineer of the Illinois Bell Telephone Company, Chicago Area, for many years. In an advisory capacity he has been interested in lead cable sheath corrosion and has participated in the design of several cathodic protection systems. He holds bachelor and professional degrees in electrical engineering and is a member of NACE and the Western Society of Engineers.

Abstract

Removal of street car rails in parts of Chicago has necessitated the use of cathodic protection for many sections of lead sheathed telephone cables. For each of several situations data have been collected as follows: 1. Type of power supply. 2. Design of ground bed. 3. Current and voltage requirements. 4. Cable sheath potentials. 5. Amount of cable protected and 6. First cost and power cost.

TABLE 1—Summary of Data

Case No.	Inst. Date	Ground	Rect. Mfr.	RATED Volts	RATED Amps.	APPLIED Volts	APPLIED Amps.	CABLE POTENTIALS Max. + Before	CABLE POTENTIALS Ave. — After	CABLE PROTECTED Feet	CABLE PROTECTED Value	Mar.-54 Inst. Cost	Mar.-54 Power Watts	Mar.-54 Ann. Cost
1	4-40	Sub-Sta.	Westingh.	3	30	2.8	16	+ .14	— .16	5800	$ 29000	$ 180	167	$ 60
2	5-41	Graphite[1]	Westingh.	12	6	15	5.5	+ .12	—1.0	17700	89000	645	47	20
3	11-43	Graphite[2,3]	Good-All	24	15	17	8	+ .36	— .10	8200	41000	1150	229	89
4	3-46	Iron Rails[2]	Westingh.	12	6	15	2	+ .10	— .12	7200	36000	580	47	20
5	8-51	Elev.[4]	G. E.	24	20	2	6	+ .10	— .50	10000	50000	370	25	12
6	7-52	Graphite[2,5]	G. E.	24	20	15	7	+1.4	—1.0	2500	12500	865	76	31
7	8-52	Elev.[4]	Westingh.	12	6	7.8	2	+1.0	— .50	660	3300	380	76	31
8	3-53	Rails[9]	Good-All	18	50	2.6	24	+ .2	— .30	5300[10]	26000	615	128	40
9	3-53	Graphite[2]	Good-All	36	15	22	4	+2.0	— .40	3000	15000	1150	110	48
10	6-53	Cables[11]	Good-All	22	12	2	2	+ .44	— .20	2860	14300	325	15	12
11	10-53	Graphite[6]	Good-All	36	30	36	21	+ .52	— .42	150000	750000	1200	900	276
AVERAGES				20	19	12.5	8.9	+ .58	— .43	19400	97000	678	165	58
12	12-49	Mg.[7]	Apex	..	..	....	.020	+ .14	— .12	228	1000	80	...	...
13	12-49	Mg.[7]	Apex	..	..	....	.035	+ .18	— .18	631	3000	95	...	...
14	3-53	Mg.[8]	Dow	..	..	....	.032	+ .25	— .05	270	1000	86	...	...
15	7-53	Mg.[8]	Dow	..	..	....	.110	+ .25	— .25	380	1500	138	...	...
AVERAGES				..	..	....	.050	+ .20	— .15	377	1600	100	...	...

1. With coke breeze.
2. With coke.
3. Changes: C. O. dismantled, rectifier removed, 1949; new rectifier installed June 15, 1950; replaced corroded wires and added graphite anodes, June 24, 1953.
4. Elevated railway structure.
5. Three failures preceded this installation.
6. Ten anodes distributed over ½ mile.
7. With Bentonite and gypsum.
8. Galvo-Pak.
9. Surface railway rails.
10. Interconnected with power cables for their protection.
11. To other well-drained cables (connected to substation).

can be protected at reasonable cost. Competitive drainage is avoided by interconnection with nearby underground systems such as that of the Commonwealth Edison Company. This company prefers to avoid insulating joints and so the cathodic protection system may become a large one handling considerable current.

In this work the cable sheath is made negative to its surroundings or, in other words, it picks up current. The resulting cathodic protection should be such as to inhibit the development of local action effects. Cables are considered protected when they are negative 0.1 volts with respect to a lead slug ground electrode. To achieve this, the negative terminal of a direct current power source is connected to the cables and its positive terminal to an artificial ground, railway power supply substation, or even the rails. In some instances the positive terminal is connected to a special control cable located in a spare duct. This has the advantage of localizing the current flow and greatly limiting its effect on other plants in the vicinity. Where the effects may be widespread, adjoining operators are invited to take part in the design and installation of the protective system. Cooperation is the keynote in electrolysis mitigation work.

Where a small amount of cable is to be protected, as in an underground dip, protection can be provided by establishing a gigantic electric cell. In this arrangement the cables or underground bodies to be protected become the cathode of the cell, while the earth is the electrolyte and the anode is a special buried electrode of metal, such as zinc, aluminum or magnesium. The potential developed between lead and zinc is less than 0.6 V and for aluminum it is about twice as great. The lead-to-magnesium potential may be as high as 1.4 or 1.6 volts under ideal conditions. However, the telephone company uses a figure of 0.8 V in practice. The cost per ampere year is said to be about $4.00 for zinc, $7.65 for aluminum and $9.00 for magnesium.

To protect underground lead sheathed cable, magnesium anodes appear most attractive. Packaged anodes are used and are expected to have a life of 10 years if no more than 100 milliamperes is delivered by the magnesium into the soil. The average current is about 40 milliamperes.

To give a better idea of the methods and results, data have been gathered on several installations in the Chicago area telephone plant and have been summarized in Table 1.

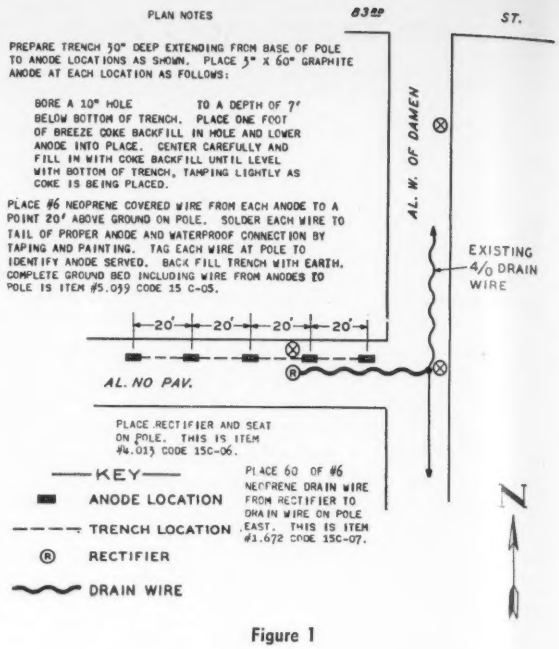
PLAN NOTES
PREPARE TRENCH 30" DEEP EXTENDING FROM BASE OF POLE TO ANODE LOCATIONS AS SHOWN. PLACE 3" X 60" GRAPHITE ANODE AT EACH LOCATION AS FOLLOWS:
BORE A 10" HOLE TO A DEPTH OF 7' BELOW BOTTOM OF TRENCH. PLACE ONE FOOT OF BREEZE COKE BACKFILL IN HOLE AND LOWER ANODE INTO PLACE. CENTER CAREFULLY AND FILL IN WITH COKE BACKFILL UNTIL LEVEL WITH BOTTOM OF TRENCH, TAMPING LIGHTLY AS COKE IS BEING PLACED.
PLACE #6 NEOPRENE COVERED WIRE FROM EACH ANODE TO A POINT 20' ABOVE GROUND ON POLE. SOLDER EACH WIRE TO TAIL OF PROPER ANODE AND WATERPROOF CONNECTION BY TAPING AND PAINTING. TAG EACH WIRE AT POLE TO IDENTIFY ANODE SERVED. BACK FILL TRENCH WITH EARTH. COMPLETE GROUND BED INCLUDING WIRE FROM ANODES TO POLE IS ITEM #5.039 CODE 15 C-05.
8329
ST.
AL. W. OF DAMEN
EXISTING 4/0 DRAIN WIRE
20'
20'
20'
20'
AL. NO PAV.
PLACE RECTIFIER AND SEAT ON POLE. THIS IS ITEM #4.013 CODE 15C-06.
KEY
ANODE LOCATION
TRENCH LOCATION
RECTIFIER
DRAIN WIRE
PLACE 60 OF #6 NEOPRENE DRAIN WIRE FROM RECTIFIER TO DRAIN WIRE ON POLE EAST. THIS IS ITEM #3.672 CODE 15C-07.
N

Figure 1

Most of the information shown is self-explanatory, but there may be questions about such items as cable potentials. These potentials were measured at one manhole and are not those found at the many other manholes even in the vicinity. The data do indicate some of the results obtained. The three figures are Maximum, Minimum and Average potentials measured between the cables and a lead ground. The amount of cable protected is a rough approximation of the length of duct system, in which the potentials were made safe, multiplied by the number of cables in the run.

Figure 1 shows a typical cathodic protection installation as ordered for one location—Case No. 9. In future arrangements, it is planned to use anode spacings of 15 feet instead of 20 feet.

In Cases 12, 13, 14 and 15 magnesium anodes are used.

More and more cathodic protection systems will probaby be required in the future as the plant and the traction systems undergo changes. The continued introduction of polyethylene covered cables will eventually make the electrolysis problem relatively easy, but new problems will probaby arise.

Use of Plastics as Materials of Construction In the Chemical Industry*

By S. W. SHEPARD

ABOUT THE AUTHOR—For seventeen years he has been occupied with materials engineering for American Cyanamid Company. This involved evaluation of materials of construction for fabrication of process equipment for almost all phases of his employer's manufacturing activities. Besides NACE he is a member of ASTM, ASM, The Electrochemical Society and the National Research Council.

Abstract

A number of case histories are given in which experimental or emergency use of plastics as materials of construction has subsequently led to their formal adoption. Principal materials referred to are the various polyester laminates, polyvinylidene chloride and fluorocarbons. The author cites the need for a reliable nondestructive test for the physical properties of reinforced plastics. Accounts are given of successful use of plastics in gas and liquid phase operations involving various corrosives.

ONE of the easiest and possibly one of the best ways to introduce plastics in the chemical industry is to use them as emergency maintenance materials. Laboratory tests can determine quickly whether a plastic has good chemical stability in contact with most chemical reagents. Plastics can be so readily fabricated that they make emergency repairs relatively simple. The information secured from these actual plant exposures is more significant even than extensive and expensive laboratory tests.

The following experiences illustrates this point: In July 1952, when stainless steels containing nickel and columbium were very difficult to secure, an old 17 chrome stainless steel nitric acid storage tank failed. It is almost impossible to field repair Type 430 or 17 chrome stainless steel tanks. They can not be welded without subsequent heat treatment and is practically impossible to do so in the field. A replacement tank would have taken many months to secure. Laboratory tests showed that a polyester resin had good resistance to the 60 percent nitric acid stored in this tank. The whole tank was completely wrapped with a fiber glass polyester covering for a fraction of the cost of a new nitric acid tank and in a matter of a few weeks time. The tank has been in service for over a year and a half and is in excellent condition.

The maintenance cost on an old steel lead-lined brick-lined alum evaporator had become very high. Laboratory tests has indicated that a polyester laminate had good resistance. A small tank was made up out of fiber glass reinforced polyester resin and was used to make pilot plant alum evaporations for several months. These tests all indicated that the laminate had good resistance. A glass fiber reinforced polyester digester was made up to replace the original digester and gave excellent service over a period of seven months. Just one month after an advertisement disclosed our use of fiber glass reinforced polyester resins for this purpose, we heard the evaporator was leaking. This evaporator processed 5000 tons of alum solution handling boiling solutions up to 240 degrees F. This indicates how relatively short time exposure tests evaluated by weight change and appearance can give misleading results. The evaporator was then patched and during 17 months since has processed 14,000 tons of alum. It will soon be replaced and retired to a less rigorous service.

How can a more reliable indication of the effects on the physical properties and permeability of fiber glass laminates be secured? Conducting destructive physical property tests is both expensive and time consuming and it takes a multiplicity of tests to determine the change in physical properties over extended periods of time. What is really needed is a good non-destructive test for the physical properties of the reinforced plastics. There is some hope that a sonic or pulse method of measuring the modulus of elasticity, as has been done by Schneider and Burton[1] for plastics and Leslie and Cheesman[2] for concrete will be adaptable to reinforced plastics. If such a test can be developed and is applicable to both laboratory and field tests, it will be possible to get a correlation between laboratory tests and field tests that are impossible by methods now being used. There are many processes where the reinforced polyester resins have given excellent service as ducts, pipelines and storage tanks and with the advent of a polyester resin laminate that maintains its strength at the boiling point of water as disclosed by H. M. Day[3] recently, their scope will be increased considerably.

About three years ago it was necessary to try to secure some material of construction that would handle the gases coming from a sulfuric acid absorption system. These gases contain a mist of sulfuric acid and considerable SO_2 and SO_3. A large quantity of air heated to 220 degrees C was to be introduced with them. While lead is excellent at the boiling point of water or a little bit above, at 220 degrees C

★A paper presented at the Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City, Mo., March 15-19, 1954.

it is not satisfactory and no one could think of a regular material of construction that appeared to be suitable for use at the top of the stack used as a mixing chamber for the hot air and the absorber gases. A very light and inexpensive trial unit was made with aluminum. After a few modifications were made to secure the desired mixing, the entire aluminum structure was covered with fiber glass reinforced furan resin. This unit has been in service for about three years and is in excellent condition. Inspection at the end of one year showed that all of the aluminum had been completely eaten away. The self-supported glass fiber reinforced furan resin was unattacked. Furan resins have been used for many different types of process equipment and for pipelines and filter press troughs. Large quantities of the furans have been used also as acid and alkali resistant cements and mortars for floors and tank linings.

A new process required the use of duct work that would handle a gas containing fair quantities of bromine at temperatures approaching the boiling point of water. This temperature is known to be too high for the vinyl resins but tests have indicated that they were chemically stable under these conditions. A complete rigid vinyl duct system was installed and except for the fact that it has distorted near the kettle where the temperature is high, it has given excellent service for several years. Generally vinyls are used where the conditions have been oxidizing or strongly alkaline and temperatures are below 160 degrees F. The author's company believes that extruded pipe will have a large market when fittings are more readily available.

It was necessary to secure some material of construction that would handle a 70 percent sulfuric acid solution at 150 degrees F. It was indicated that the polyvinylidene chloride resin called Saran had excellent resistance. 1000 feet of Saran-lined steel pipe has been in service with this material over two years with no indication of trouble. This material also has been used as self-supporting pipe and on steel lined pipe in many locations. It was very pleasing to find in one application where it was handling a hydrochloric acid slurry, that an additional advantage was that the organic solids did not build up on the plastic lining.

The fluorocarbons, such as Teflon and Kel-F have given wonderful service as packing and gasket materials. Teflon was used as an emergency baffle in molten guanidine hydrochloride operating at 205 degrees C where it gave excellent service. The excellent service of this material in the relatively small quantities in which they have been used in valves and packing has lead to a tremendous desire to use them for larger parts of the equipment when and if a suitable lining technique is developed.

It would certainly be appreciated if any readers of this article could suggest a good non-destructive test for the physical properties of reinforced plastics which would make the testing of these materials for use in the chemical industry more reliable. The best alternative to this type testing now is actual use in some part of the equipment under actual plant conditions. The easiest way to get material introduced under these conditions is when a maintenance emergency arrives. The more available these materials are to the maintenance crews, the faster they will be introduced into chemical equipment. When their remarkable properties are more widely appreciated, their use in the chemical industry will cut down maintenance costs appreciably.

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Chromate for Corrosion Control In Methanol Antifreeze*

By GEORGE E. BEST and EUGENE A. ROCHE

Introduction

TECHNICAL LITERATURE and industrial practice abound with a wide variety of applications of hexavalent chromium chemicals for inhibiting corrosive attack of metals.[1,2,3] Among the most familiar is the use of chromate or bichromate in recirculating cooling systems, as in internal combustion engines.[3,5] This is true not only of automobile and truck gasoline engines but also of gas engines utilized extensively by the petroleum industry and of both stationary and automotive Diesel units.[6] In fact, adoption of chromate for Diesel locomotives, particularly to allay the aggravated attack on cylinder liners otherwise occurring because of cyclical mechanical stressing, has achieved virtually universal acceptance on the basis of proven merit.[7,8,9,10]

Heretofore caution has prevailed regarding the use of chromate in alcohol antifreeze,[6] although satisfactory experience with methanol solution in mercury-arc rectifier equipment has been recorded[11] and compatible effectiveness in the presence of other organic media is not unknown, e.g., petroleum products pipe lines,[6] slushing oils,[12] chromate primers,[13,14] organic weed killers[15] and aircraft fuel tanks.[16] Obviously many organic substances cannot resist the oxidizing effect of hexavalent chromium, with reduction of the latter to trivalent form. Thus it was the inability to predict with assurance whether chromate would be satisfactorily stable in methanol antifreeze solution under the conditions of temperature and metal contact in automotive equipment service that led to the field testing program to be described. Beyond the point of compatibility, the only objectives were

1. to learn whether a single inhibitor dosing of reasonable magnitude would carry through the entire antifreeze season without replenishment or special attention, and
2. to determine whether a buffer such as borax, phosphate or silicate would improve stability.

Scope of Investigation

Extending over two winter seasons, operating service tests were carried out on fourteen automobile passenger cars, two gasoline-engine driven trucks and one Diesel tractor. Of the nine passenger cars participating during the first season, four remained to continue the second season, the other five having been sold. Replacements were allotted new test identification. Unless otherwise indicated the cooling system was simply flushed with water before charging with antifreeze solution—except that if it had been operating with chromated water, about 1 oz. Na_2CrO_4 per gallon, it was merely drained without flushing.

Chromate in the form of Na_2CrO_4 was tested at two nominal concentration levels, i.e., 2000 ppm (0.27 oz. per gal.) and 5000 ppm (0.67 oz. per gal.), with

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EUGENE A. ROCHE—Now a sales engineer in the Rustproofing and Metal Working Chemicals Div., American Chemical Paint Co., Ambler, Pa., Mr. Roche has a BSChe from Johns Hopkins University. He joined the research and developmen department of Mutual Chemical Company in 1941 where he studied the uses and properties of chromium compounds. After serving as an instructor in the air force 1943-45 he returned to technical service work at Mutual.

Abstract

Tests are described covering two winter seasons of automobile and truck operation with methanol antifreeze containing chromate, with and without supplementary additions of borax, tetrasodium pyrophosphate or sodium metasilicate. From 2 to 6 coolant inspections were made in the 17 vehicles tested over operating periods ranging from 1.6 to 5.8 months. Results demonstrated the chemical stability of chromate in this use. Laboratory observations indicated that compatibility depends on shielding from light. Engine disassembly and examination confirmed that cooling systems in which chromate was used not only were protected from corrosion, but remained cleaner in regard to surface deposits than uninhibited systems.

Because chromate tends to loosen rust and deposits, pre-cleaning before charging old systems with chromated methanol antifreeze is recommended. The advantage of using chromate in cooling water to prevent corrosion and deposit formation during the summer is underlined.

For packaged antifreeze the low solubility of sodium chromate in methanol was found to necessitate adding some water in order to obtain an adequate inhibitor concentration. An alternative is to use lithium chromate which is amply soluble in methanol.

★A paper delivered at the Ninth Annual Conference, National Association of Corrosion Engineers, Chicago, Ill., March 16-20, 1953.

and without supplementary additions of borax, tetrasodium pyrophosphate or sodium metasilicate. In three instances the chromate equivalent of sodium bichromate plus soda ash was added instead of chromate to obtain direct confirmation that results would be identical. In hot solution, where bicarbonate is not stable, 1 part $Na_2Cr_2O_7 \cdot 2H_2O$ plus 0.36 part Na_2CO_3 is equivalent to 1.087 parts by weight Na_2CrO_4 (pH 8 or higher). In view of the known reactivity between hexavalent chromium and methanol in acidic solutions and the optimum range for corrosion control with chromate being pH 7.5 to 9.5, there was no point in carrying out antifeeze compatibility tests below pH 8.

Commercial, uninhibited, synthetic methanol was mixed with Baltimore city water to make the antifreeze solutions. Mostly 1 part methanol and 2 parts water by volume were used, although the methanol concentrations were somewhat different than this in several cases to suit the individual car owners' wishes. Freezing point determinations were made with the familiar specific gravity-type antifreeze tester. Small antifreeze solution samples were withdrawn about once a month for measuring chromate concentration by colorimetric comparison with standard solutions (after diluting to the range of 100 to 500 ppm) and for electrometric pH measurement. Initial and final chromate concentrations were confirmed by chemical analysis.

TABLE 1—Test Car Selection and Driving Record 1949-1950 Season

Car	Year and Make	Test Period (months)	Total Mileage	Average Miles Per Month	ANTIFREEZE PROTECTION F.P. Minimum	°F. Maximum
A	1949 Packard....	5.3	1007	190	— 7	+ 3
B	1941 DeSoto....	5.8	2790	480	— 7	— 6
C	1949 Cadillac....	5.3	6227	1180	— 7	0
D	1942 Oldsmobile.	2.0	**	1000*	—14	**
E	1949 Dodge.....	5.0	2314	600	+ 3	+13
F	1942 Ford.....	5.6	3541	632	—16	— 7
G	1948 Buick.....	3.7	4000	1080	—16	—14
H	1950 Buick.....	1.6	1137	710	+ 7	**
I	1940 Buick.....	4.6	1708	370	— 3	+ 9

* Estimated
** Not Obtained

TABLE 1A—Test Car Selection and Driving Record 1950-1951 Season

Car	Year and Make	Test Period (months)	Total Mileage	Average Miles Per Month	ANTIFREEZE PROTECTION F.P. Minimum	°F. Maximum
A	1949 Packard....	5.3	1222	230	— 7	**
C	1949 Cadillac....	5.3	5041	950	0	+10
J	1948 Ford Truck.	5.4	**	350*	—14	— 7
K	Diesel Tractor (new).....	5.5	**	**	— 7	— 6
L	1940 Chevrolet..	5.6	2720	480	— 7	— 6
M	1949 DeSoto....	5.4	**	900*	— 7	— 6
N	1950 Ford.....	4.1	**	800*	—18	— 7
O	1946 Ford Truck	5.4	**	630*	0	+ 6
E	1949 Dodge.....	5.5	3137	570	— 7	— 7
P	1949 Lincoln....	5.7	3200	560	—16	— 3
H	1950 Buick.....	5.3	4199	800	— 7	— 6
Q	1949 Plymouth..	4.8	4201	880	— 7	— 7

* Estimated
** Not Obtained

TABLE 2—Observations and Adjustments 1949-1950 Season

Car	Prior Coolant	Preparatory Cleaning	No. of Inspections	Antifreeze Replacements	Reason—Comment
A	Water containing soluble oil	None	6	One—end 2nd month*	Down to 500 ppm Na_2CrO_4; reduction of Cr^6
B	Glycol antifreeze solution	None	4	One—end 2nd month*	Down to 225 ppm Na_2CrO_4; reduction of Cr^6
C	Glycol antifreeze solution	None	6	One—end 2nd month	Cr^6 reduced by glycol residue
D	Water	None	2	None	.....
E	Chromated water	None	4	None	.....
F	Water	Oxalic acid solution	5	Three during first month	Progressive loosening of old rust scale
G	Water	None	4	One—1st month One—2nd month	Rust loosening Rust loosening with overheating
H	None**	Bichromate solution**	2	None	.....
I	Water	None	4	Three	Progressive loosening of old rust scale

* Operated one-half hour with 1.0 lb. $Na_2Cr_2O_7 \cdot 2H_2O$ per gallon before replacing antifreeze.
** New car received from factory with radiator dry. Operated one day with 1.0 lb. $Na_2Cr_2O_7 \cdot 2H_2O$ per gallon before charging antifreeze.

Discussion of Results

Tables 1 and 1A—There was no reason to anticipate differences associated with make or age of car, or variation in mileage but this information is included as an essential part of the record of the test program.

Tables 2 and 2A—Early in the first season two points became clear, both having to do with the prior history of the cooling system (See Table 2):

1. Residual organic materials, such as soluble-oil inhibitors or glycol antifreeze which tend to coat metal surfaces and do not rinse off readily on flushing with water, may result in loss of chromate by chemical reduction. Chromium reduction was reflected in the high pH values recorded for Cars A and B, Table 3, inasmuch as reduction of hexavalent chromium releases alkali from Na_2CrO_4. The idea behind briefly treating these systems with a moderately strong sodium bichromate solution was to complete the reaction between hexavalent chromium and oxidizable organic residue, in the knowledge that this proceeds much more rapidly with increase in hexavalent chromium concentration and lowering of pH through the use of bichromate rather than chromate.
2. Residual rusty scale tends to be loosened and released and may interfere with adequate coolant circulation if allowed to accumulate in sufficient quantity. (This unexplained effect of chromate has been noted in industrial cooling systems, also.)

Both of the above observations emphasize the importance of keeping the cooling system clean and corrosion-free during the summer months by maintaining

TABLE 2A—Observations and Adjustments 1950-1951 Season

Car	Prior Coolant	Preparatory Cleaning	Number of Inspections	Antifreeze Replacements
A	Chromated Water.....	None	3	None
C	Chromated Water.....	None	4	None
J	Water.....	None	3	None
K	Water Containing Soluble Oil.....	None	3	None
L	Chromated Water.....	None	4	None
M	Water.....	None	4	None
N	Chromated Water.....	None	4	None
O	Water.....	None	3	None
E	Chromated Water.....	None	4	None
P	Chromated Water.....	None	4	None
H	Chromated Water.....	None	5	None
Q	Commercial Methanol*.... Antifreeze Solution	Trisodium* Phosphate	4	None

* When delivered new, this car had soluble oil in the cooling water. Operated 1949-1950 with commercial methanol antifreeze which was removed at end of season. Car was operated two days with 0.5 lb. Na_3PO_4 per gallon, flushed and 5000 ppm chromated water was used during the summer.

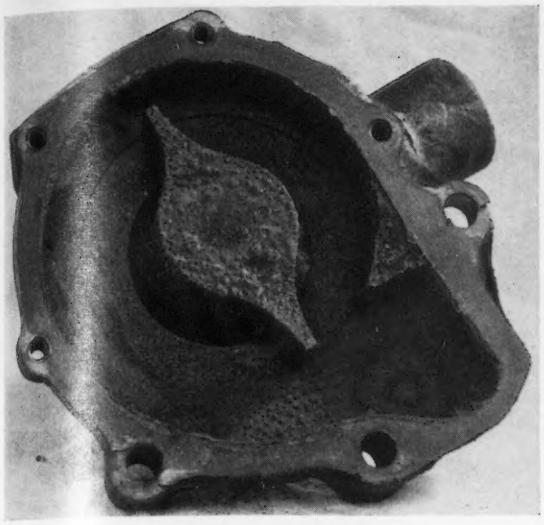

Figure 1—Water pump of 1949 Plymouth in which no chromate was used, before cleaning. Note blistery scale.

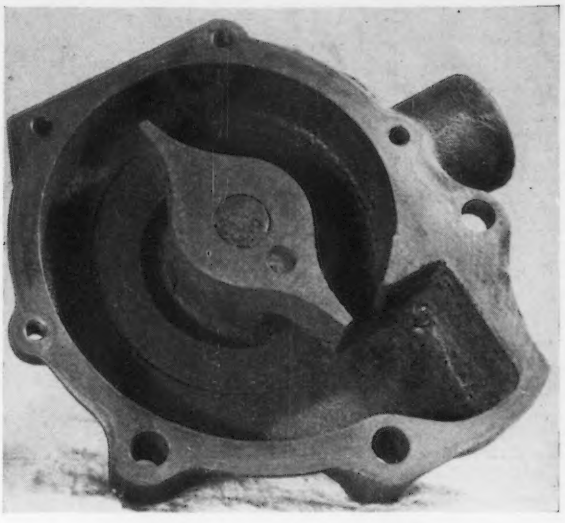

Figure 1A—Water pump after cleaning. Note pitting of impeller and casing.

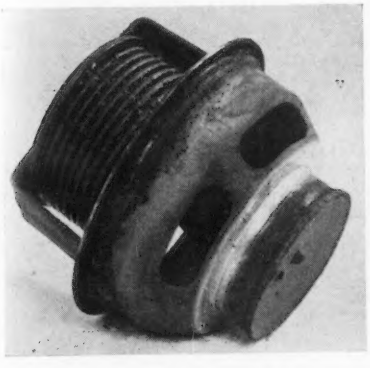

Figure 1B—Thermostat before cleaning. Note accumulated deposits on bellows.

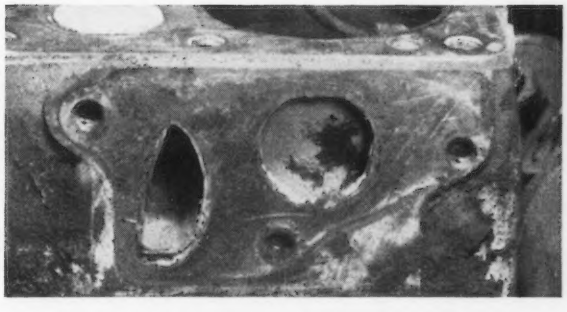

Figure 1C—Looking into cylinder block water channels. Note accumulated deposits on interior surfaces.

a protective concentration of inhibitor in the cooling water in order to avoid complications after antifreeze is charged. It is notable that there was complete freedom from these complications during the second testing season as a consequence of forewarning all the participants so that the cooling systems were cleaned, where needed, considerably before the antifreeze season. Hence there was no preparatory cleaning as a part of the second season testing program. It is pertinent to add that a non-metallic coating, whatever its cause, adversely affects heat transfer and is generally undesirable on cooling system surfaces.

Using chromate as an inhibitor apparently tends to keep the surface clean, either by oxidizing organic material or loosening rusty scale. However, these effects occur gradually and the former causes loss of inhibitor by chemical reduction. Thus a thorough pre-cleaning is indicated for most satisfactory operating performance. Once cleaned, all of the test cars performed excellently.

Actually two more seasons—four in all—of wholly satisfactory operating experience with chromated methanol antifreeze solution have now passed. This arises from its popularity with the car owners who took part in the investigation so that it has been continued in use through the 1951-1952 and 1952-1953 seasons by them and by some of their associates as well.

Tables 3 and 3A—The amount of hexavalent chromium consumed in maintaining metal surface passivity, i.e., a condition of protectiveness, is virtually insignificant in an automotive cooling system inevitably subject to mechanical losses of coolant due to overfilling, draining for repairs, etc. No specific effort was made to minimize these losses in this testing program, in order to assure the results having practical significance.

So far as stability or compatibility of chromate with methanol is concerned, no attempt was made to obtain precise information in terms of the weight of chromate which was reduced by methanol over an average antifreeze season. It is very evident from the tabulated data that a single dosing of either 2000 or

5000 ppm Na_2CrO_4 is sufficient to maintain a protective inhibitor concentration in an automobile or truck cooling system for an antifreeze season of 4 to 6 months. Obviously a major replacement of antifreeze would need to be accompanied by inhibitor replenishment.

Inasmuch as chromate alone was found chemically compatible in methanol antifreeze solution, the results provide no basis for stating that borax, phosphate, or silicate assists insofar as stability is concerned. On the other hand, it is apparent that none of these is adverse in this respect. Moreover, it is reasonable to presume that the buffering effect of borax might be advantageous, particularly to minimize pH rise in systems having aluminum or magnesium components.

General—Some additional discussion is appropriate in anticipation of questions about organic antifreezes other than methanol. Inasmuch as supporting data are not offered, this information should only be interpreted as having tentative unconfirmed status, based on limited indications rather than substantiating results.

Chromate appears not to react rapidly with pure ethanol in mildly alkaline solution, e.g., pH 8 to 9. However, it is definitely reactive with some of the common denaturants. Thus if chromate were to be employed with ethanol antifreeze, it would need to be added in amounts sufficient to allow for loss in part where the denaturant is susceptible to oxidation. The small amount of hydrous chromic oxide formed will remain in suspension in the coolant with little likelihood of impairing circulation.

The status of isopropanol is uncertain. Unrelated mechanical problems interfered with the test started on several cars. Accordingly until further information is obtained, use of chromate in isopropanol antifreeze solution should be viewed as investigative.

Indications are that the glycols are too readily reactive for more than temporary sustainment of hexavalent chromium in automotive cooling systems. Isolated reports of beneficial effect and satisfactory operating experience from chromate in glycol antifreeze persistently recur, but this combination will not be recommended until the merit of chromium under such conditions has been scientifically elucidated. However, it was observed from a car test not included in this report, that the hydrous chromic oxide resulting from adding 1 oz. Na_2CrO_4 per gallon to ethylene glycol antifreeze brought about no interference to circulation even though chromium reduction apparently was complete when checked at the end of four months.

Figure 2—Thermostat of 1949 Dodge (Car E) in which chromate was used, before cleaning. Note cleanliness and lack of deposits.

Recommended Practice

The suggestions for procedure and practice in using chromated methanol antifreeze follow the general recommendations published by the National Bureau of Standards,[17] the Society of Automotive Engineers,[18] and the American Society for Testing Materials,[19] with the specific details appropriate to using chromate inserted:

1. Inspect radiator, hoses, thermostat and cylinder head joint and make repairs required to insure having a tight system with the thermostat adjusted properly and in good working order. Year-around use of chromate assists in leak detection, by virtue of the high coloring power of even traces of chromate residue left upon evaporation.
2. In the absence of positive assurance that the cooling system is clean as a result of regular use of chromate inhibitor in the past, clean the system with an effective cleaner. Both acid and alkali cleaners are available; oxalic acid is frequently employed and mixtures of bichromate or chromate with soda ash or trisodium phosphate are common.[20] Follow the manufacturer's directions in using the cleaner.
3. Flush thoroughly with water, draining the engine block as well as the radiator. Repeated filling and draining may be needed to flush heaters, etc. by dilution where actual draining will not occur.
4. Neutralization with alkaline solution is highly desirable after acid cleaning. If no directions for neutralizing are given, dissolve about 1 oz. sodium bicarbonate (baking soda) or sodium carbonate (washing soda) per gallon of cooling system capacity; add this solution and fill with water. Run the motor at least 10 minutes, and drain.
5. Flush again if given directions so indicate, otherwise charge with methanol to give desired antifreeze protection.
6. Add 1 oz. sodium chromate (Na_2CrO_4) per gallon of total cooling system capacity. This also may be added in the form of sodium chromate tetrahydrate ($Na_2CrO_4 \cdot 4H_2O$), in which case 1.5 oz. per gallon is required to provide the same inhibitor concentration. Alternatively, a mixture of 0.92 oz. sodium bichromate ($Na_2Cr_2O_7 \cdot 2H_2O$) and 0.33 oz. soda ash (Na_2CO_3) may be applied with some saving in cost where large quantities are involved. This suggested concentration—7500 ppm—provides a greater factor of safety against mechanical loss and dilution than necessary as indicated by the testing program, but in the absence of other considerations the insignificant cost involved prompts full sufficiency of inhibitor dosage. For cars or trucks under regular inspection, inhibitor concentration preferably should not be allowed to fall below 1000 ppm.
7. Be sure the antifreeze solution maintains a pronounced yellow color throughout the season. Car or truck fleets may wish to make quantitative colorimetric analysis of inhibitor concentration by conventional techniques[21] and where opportunity is afforded it would be well to ascertain that the antifreeze solution develops a pink color with phenolphthalein indicator.
8. At the end of the winter season simply allow the methanol to evaporate gradually leaving the inhibitor for summer protection, or drain and flush and add 1 oz. sodium chromate per gallon to the cooling water.

Figure 2A—Looking into cylinder block water channels. Note that interior surfaces are free of heavy deposits.

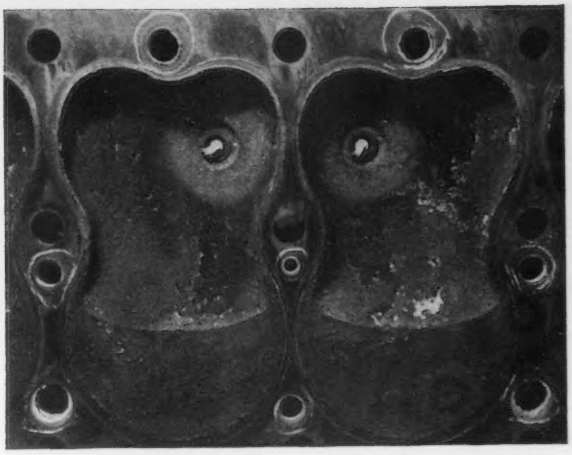

Figure 2B—Underside of cylinder head. Note that water ports (outlined with chalk) are substantially free of deposits.

Packaged Antifreeze

The very limited solubility of the common chromates in methanol, e.g., 0.35% Na_2CrO_4 at room temperature,[22] prevents simply adding sodium chromate to methanol antifreeze before packaging, for dilution in use would decrease the inhibitor concentration to too low a level for full-season protection.

There are two ways in which this can be overcome. The first is through adding a small amount of water to the methanol. The amount of water required depends upon the concentration of inhibitor desired, but it would probably not be necessary to increase the volume by more than about 10 per cent. (See Table 4).

A second solution to this problem is afforded by lithium chromate. Even the anhydrous form of this compound is soluble in absolute methanol at 0 degrees C to the extent of 13 per cent Li_2CrO_4 by weight.[22] The common dihydrate form, $Li_2CrO_4 \cdot 2H_2O$, is somewhat more soluble due to contributing its water of crystallization. The suitability of lithium chromate in place of sodium chromate in methanol has been confirmed by car trial extending over two years.

The presence of chromate in packaged methanol antifreeze assures indefinitely long shelf life of tinned steel containers from the standpoint of internal metal protection. In conjunction with this investgation, closed tin cans containing chromated methanol, with and without 5 per cent water addition, have been stored for three years without evidence of reaction between the methanol and sodium chromate, with perfect preservation of the internal metal surfaces.

In making solubility determinations of lithium chromate in methanol, it was noted that solutions contained in transparent glass flasks gave evidence of chromium reduction rather quickly, whereas those contained in bottles shielded from the light by covering with black tape were stable.[22] Similar observations have been noted with sodium chromate, thus providing another example of light catalyzing the oxidation of certain organic substances by hexavalent chromium. This finding may explain the good field experience reported in the past—better than anticipated from laboratory tests—with chromate in

TABLE 3—Stability Data 1949-1950 Season

Car	STARTING CONDITIONS: Nominal Na_2CrO_4 ppm	STARTING CONDITIONS: Other Additive ppm	ADDITIONS DURING TEST*: Total Amount	ADDITIONS DURING TEST*: No. of Additions	INHIBITOR CONCENTRATION ppm Na_2CrO_4: Average	Final	pH Range
A	2000	None	0	0	1200	1600	8.6—11.3
B	2000	None	0	0	1800	2000	8.2—11.4
C	5000	None	2 oz. Na_2CrO_4	1	3300†	5000	9.2—10.3
D	5000	None	0	0	4400	3500	8.4— 8.7
E	2000	10,000[1] borax	0	0	2100	2000	9.1— 9.2
F	2000	10,000[1] borax	1 oz. Na_2CrO_4 4 oz. Borax	1	1400	1200‡	9.1— 9.5
G	2000	5000[2] phosphate	0	0	1700	1400	11.1—11.2
H	2000	5000[2] phosphate	0	0	2100	1700	8.1— 9.7
I	2000	5000[2] phosphate	0	0	1400	1700	11.0—11.3

* Exclusive of total antifreeze replacement.
† Low due to failure to allow for 1.5 gallons of coolant volume for rear seat heater during first three months. The addition noted was to bring concentration to 5000 ppm.
‡ Low final concentration occasioned by dilution on account of radiator leak.
[1] Calculated as $Na_2B_4O_7 \cdot 10H_2O$.
[2] Tetrasodium pyrophosphate calculated as $Na_4P_2O_7$.

TABLE 3A—Stability Data 1950-1951 Season

Car	STARTING CONDITIONS: Nominal Na_2CrO_4 ppm	STARTING CONDITIONS: Other Additive ppm	ADDITIONS DURING TEST: Total Amount	ADDITIONS DURING TEST: No. of Additions	INHIBITOR CONCENTRATION ppm Na_2CrO_4: Average	Final	pH Range
A	2000	None	0	0	1450	750	8.9— 9.8
C	5000	None	0	0	5100	2750*	8.5— 8.7
J	5000	None	0	0	4300	4400	8.8— 8.9
K	5000[1]	None	0	0	5200	4400	8.3— 8.4
L	5000[1]	None	0	0	5050	4400	8.9— 9.0
M	5000[1]	None	0	0	4450	4400	9.0— 9.4
N	2000	5000[2] borax	0	0	1675*	900*	8.6— 8.9
O	2000	2000[2] borax	0	0	1650	1375	8.1— 8.9
E	2000	2000[2] borax	0	0	2400	1925	8.4— 8.8
P	5000	5000[2] borax	0	0	4025	2475	8.5— 8.8
H	2000	5000[3] phosphate	0	0	2700	2200	8.5— 8.8
Q	5000	100[4] silicate	0	0	4900	3125	8.4— 9.0

[1] Added in the form of a mixture of one part $Na_2Cr_2O_7 \cdot 2H_2O$ and 0.36 part Na_2CO_3.
[2] Calculated as $Na_2B_4O_7 \cdot 10H_2O$.
[3] Tetrasodium pyrophosphate calculated as $Na_4P_2O_7$.
[4] Sodium metasilicate calculated as Na_2SiO_3.
* Some dilution due to coolant leakage.

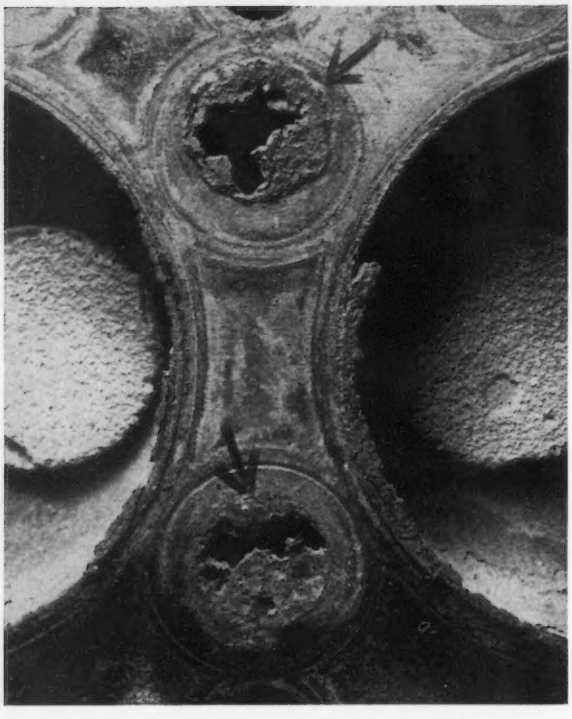

Figure 3—Top view of cylinder block of 1949 Buick in which no chromate was used. Note that the water ports (indicated by arrows) are almost closed by deposits.

TABLE 4
Solubility of Sodium Chromate in Methanol Solutions

	Na_2CrO_4 Concentration	
	Lab. Temp.	2 °C
100 methanol [1]	0.35%[3]	....
95 methanol-5 water [2]	0.52	0.49%[3]
90 methanol-10 water [2]	1.25	0.61
80 methanol-20 water [2]	2.54	0.68

1. Absolute methanol
2. Parts by volume
3. Percent by weight

various antifreeze solutions, i.e., because operating systems ordinarily are wholly closed and shielded from the light.

Corrosion-Inhibition Effectiveness

Although determining the stability of chromate was the purpose of the investigation, there was afforded an excellent opportunity to confirm the protectiveness of chromate when used in engine coolant.

Cars E and H (see tables) were selected for detailed inspection because of the known continuous use of chromate from the date of purchase. In the case of Car E the radiator was removed and sectioned, the water pump removed and disassembled, and the cylinder head removed. Car H was similarly examined except that the cylinder head was not removed, but the condition of the water channel in the cylinder block was clearly evident at the water pump site. This was done in the spring of 1953, after both cars had used chromated methanol antifreeze for four full winter seasons.

An extremely thin surface film was apparent generally over interior surfaces but there was not the slightest sign of metal attack. The hoses were in excellent condition, still flexible with no cracking or checking on the inside. Thus it was directly established that chromate provides complete corrosion inhibition, without any incidental disadvantages such as the formation of surface coatings that might impede heat transfer or cause hose deterioration.

Partial examination was made of two cars, comparable in manufacture, age and mileage to those discussed above, to obtain an indication of what can occur in the absence of chromate. (In neither case had any record been kept of the commercial antifreezes used.) The presence of blistery scale was very evident, extending to partly close the cylinder block ports in one case and pitting was apparent in the water pump of the other. These conditions are illustrated in selected photographs.

Conclusions

1. Results from a field testing program extending over two winter seasons show that chromate can be used as a corrosion inhibitor compatibly in methanol antifreeze solution and that a single dose of 1 oz. Na_2CrO_4 per gallon of cooling capacity, or even appreciably less, is sufficient for the usual antifreeze season under average conditions of car operation.
2. The tendency of hexavalent chromium to react with and be reduced by readily oxidizable organic residues and gradually to loosen old rust scale, emphasizes the importance of pre-cleaning the cooling system unless it has been maintained in good condition.
3. Slight alkalinity of the antifreeze solution, pH 8 or slightly higher, is important both for stability of the chromated methanol and for maximum inhibitor effectiveness. Thus conjunctive use of an appropriate buffer, such as borax, may be advantageous, especially with water of questionable quality.
4. Use of sodium chromate in packaged methanol antifreeze is made feasible by using methanol containing a small amount of water. An alternative is the use of lithium chromate which is amply soluble in anhydrous methanol.
5. Shielding chromated methanol solution from light is an important factor in chemical stability.
6. The ability of chromate to provide complete corrosion inhibition in engine coolant, when used under conditions of chemical stability, has been further confirmed.

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DISCUSSION

Discussion by Allen M. Montgomery and Herbert C. Rutemiller, Aluminum Company of America, Cleveland:

The effectiveness of chromates as inhibitors of corrosion, not only for ferrous materials but also for wrought and cast aluminum alloys as well as many other metals, has been recognized for a long time. The present paper affords added evidence of the value of these inhibitors. However, a word of caution should be introduced regarding general use of chromates in methanol antifreeze solutions. Aluminum Research Laboratories of Aluminum Company of America has conducted extensive engine and road tests to determine the corrosivity of various coolant solutions to aluminum alloy cylinder heads mounted on cast iron cylinder blocks. It was found that certain anodic inhibitors, which may be protective to iron or aluminum separately, act as accelerators of galvanic corrosion in automotive cooling systems. The addition of chromates to alcohol-base antifreeze compounds was particularly harmful from this standpoint in these tests. Therefore, it is advised that chromates as corrosion inhibitors be avoided in cooling systems where galvanic couples of aluminum alloys and other metals are present. A 1% solution of naphthenic base soluble oil is currently recommended as a satisfactory inhibitor although other types of inhibitors are being investigated.

Reply by George E. Best and Eugene A. Roche:

We appreciate the note of precaution regarding bimetallic systems in which aluminum is one component. Aluminum tends to corrode sacrificially when coupled to steel or more noble metals, thus present a difficult system to protect satisfactorily. A comparatively small anodic area of aluminum, together with chloride accumulation in the cooling water due to evaporation, aggravates the problem in an engine. Although we have had field reports of using chromate with satisfying inhibitive effect in automobile and Diesel engines with aluminum cylinder heads, these reports have not applied specifically to alcohol antifreeze coolants. It is pertinent to emphasize that the problem of questionable protection from chromate occurs only when aluminum is in direct contact with less active metals for, as Messrs. Montgomery and Rutemiller have so properly stated, chromate is highly protective to aluminum by itself; thus chromate can be utilized in an all-aluminum system or where the exposed surface area of dissimilar metals is small in relation to the surface of aluminum.

ERRATUM

Temporary Ground Beds by the Roll—A Technical Note. *Corrosion*, Vol. 10, No. 3, 100 (1954) Mar.

Insert the following in the Contents Page iii, following the article "Sea Water Immersion Trials of Protective Coatings":

Temporary Ground Beds by the Roll—A Technical Note
By B. J. Whitley **100**

Industrial Applications of a Method For Measuring Small Amounts of Corrosion Without Removal of Corrosion Products*

By ANDREW DRAVNIEKS and HORACE A. CATALDI

Introduction

THE ELECTRICAL resistance method for measuring the extent of corrosion of a metal utilizes the fact that metals and alloys have much lower specific electrical resistances than their corrosion products. Since the electrical resistance of a metal depends on its cross-sectional area, a decrease in thickness of a specimen due to corrosion may be evaluated quantitatively from the increase in resistance. A number of investigators[1, 2, 3, 4, 5, 6] have used this principle for the solution of special problems in corrosion research. The method, however, deserves wider adaptation to industrial laboratory and field investigations. The purpose of the present paper is to outline the numerous advantages and the limits of applicability of the method, to describe a practical form of specimen and apparatus and to illustrate possible applications by several examples.

Advantages and Limitations of the Method

The principal advantages of the electrical resistance method for measuring corrosion rates stem from the fact that cleaning of specimens is rendered unnecessary. Cleaning procedures are cumbersome and may lead to serious errors, especially if the amount of corrosion is small. The electrical resistance method, requiring no cleaning, is capable of very high sensitivity. For example, with metal specimens 0.001-inch thick and with the apparatus described, the resolution is of the order of 0.2 to 0.4 microinches (5×10^{-7} cm) decrease in thickness. This corresponds to a weight loss of 0.004 mg./cm^2 for a metal of density 8 gm/cm.[3] This sensitivity is of obvious advantage where the corrosion rates to be measured are very low.

For convenience, the resistance method may be considered a rapid "electrical weighing," sensitive only to the amount of metal which remains uncorroded. Scales, dirt, coke, excess of corrosive substance and other deposits do not affect the resistance of the specimen. For this reason the method may be used in any corrosive medium and may be adapted easily to produce a continuous record of the progress of the corrosion without removing the specimen from the reaction zone.

If, as in the case of alloys, selective oxidation occurs, results obtained by gravimetric methods are of doubtful value but changes in electrical resistance in some cases may be of more practical significance, because both electrical resistance and strength of the specimen depend on the residual metallic core. In this connection, it may be noted that the electrical method has been used to determine intergranular susceptibility of austenitic stainless steel.[7]

★ A paper presented at the Tenth Annual Conference, National Association of Corrosion Engineers, Kansas City, Mo., March 15-19, 1954.

ANDREW DRAVNIEKS—Senior Project Engineer in the Engineering Research Department at Standard Oil Company (Indiana) he holds a ChE degree from University of Latvia (1938), did advanced work there and at Marburg University, Germany, and received a PhD from Illinois Institute of Technology in 1949. He has been instructor at the University of Latvia and technical director of a paint firm in that country as well as research associate with Illinois Institute of Technology. His work centers on paint technology, polarography, surface chemistry and the kinetics of corrosion processes, especially at elevated temperatures.

HORACE A. CATALDI—When the work reported in the paper included in this symposium was done he was Assistant Project Engineer in the Engineering Research Dept., Standard Oil Company (Indiana) and engaged full time in corrosion research. He joined Standard Oil in 1950. He is now in the Materials and Processes Laboratory, Large Steam Generator Dept., General Electric Company, Schenectady, N. Y., working on high temperature corrosion. He has a BS in chemical engineering from College of the City of New York (1940) and a PhD in chemical engineering from the University of Illinois in 1949. He was employed as a physicist by the Navy Department during the war and worked as a physical chemist and assistant department supervisor in electronics at Oak Ridge.

Abstract

The electrical resistance technique described here has been developed for practical application to corrosion tests of industrial laboratories. The technique can detect corrosion losses to a fraction of a microinch, does not require removal of corrosion products or other deposits and can be adapted to virtually all corrosive media and conditions. The main usefulness of the method is in establishing the relative corrosivities of media which are closely alike. Several typical applications are given: 1) the determination of the relative corrosivities of crude oils at refinery temperatures, 2) the indentification of the source of the corrosive components responsible for the attack in a vis-breaking unit charging a complex feed mixture, 3) the determination of the corrosivity of sulfuric acid sludges, 4) a quantative assessment of oil-soluble rust inhibitors, and 5) the determination of the corrosivity—to lead—of oxidized lubricating oils as a function of the degree of oxidation of the oils.

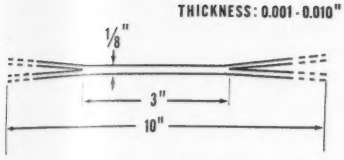

Figure 1—Typical corrosion specimen used for the method based on measurement of the change in the electrical resistance. The specimen is cut from a 10-inch by ⅛-inch strip by slitting from both ends. Specimen thickness is 0.001-0.010-inch.

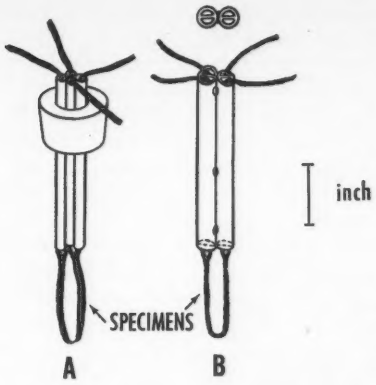

Figure 2—Typical specimen holders. A. Four Pyrex tubes in a neoprene stopper. B. Assembly of two double-bore fused quartz tubes, fused together.

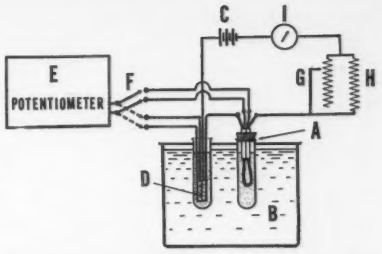

Figure 3—Measuring circuit. A, specimen holder; B, water thermostat; C, 6-volt storage battery; D, managin resistor, 0.2-0.5 ohms; E, potentiometer, 0-80 millivolt range, to 0.01 mv.; F, selector or knife switch, thermocouple (millivolt) quality; G, ten-turn Helipot or similar variable resistor, 50 ohms; H, constant resistor, 10-100 ohms, low temperature coefficient; I, 1000 millampers DC miliammeter. Thermostat regulating parts and stirrer are not shown.

Finally, the electrical measurements are simple, rapid and precise; and they require no apparatus not ordinarily available in most laboratories.

In order to achieve increased sensitivity and simplicity of calculation, it is convenient to use specimens in the form of ribbons in which thickness is proportionately very much smaller than width. The limits of application of this technique arise mostly from the use of these thin specimens, which are preferably less than 0.01-inch (0.25 mm) thick. For instance, tests with cast metals are impractical. Most other alloys and metals, however, may be obatined commercially as thin ribbon, sheet or foil.

The method is best applied to those cases in which the corrosion is reasonably uniform and in this respect it resembles the gravimetric methods. Pitting, for instance, cannot be evaluated by either of these methods alone. Empirically, by producing artificial defects in corrosion specimens, it has been determined that the weight-loss and resistance-change methods give practically the same results, provided the tests are not prolonged beyond the point where a 20 percent increase in resistance is obtained. Normally this range includes moderate pitting. In cases of extreme non-uniformity, the change of resistance of the specimen will depend on the geometrical distribution of the pits.

For experiments at high temperatures, it is necessary to determine whether changes in resistance may result from the effect of heat treatment, as distinct from the effect of a reduction in cross-section due to corrosion. Extraneous heat treatment effects may be eliminated by "preannealing" specimens at the test temperature in a vacuum or in an inert atmosphere; or alternatively, a correction may be made from the results of a test run. As an example, steel shim stock decreases in resistance by approximately one percent when heated in a non-corrosive atmosphere between 600-800 degrees F; the change in resistance however is negligible if the steel has been previously annealed at 1200° F.

In the rare cases where highly conductive sulfides form,[8] the corrosion products may compensate partially for the loss of conductance caused by the decrease in metallic cross-section. In such cases, a correction factor may be obtained and used advantageously.[5] However, sulfides formed in industrial media are much less conductive than the pure sulfides and do not seem to interfere with the corrosion measurements.

Finally, because of the sensitivity of the electrical resistance method, the results obtained may represent mainly the rates of corrosion in the initial stages. These may differ greatly from those obtained with more conventional laboratory specimens and field coupons. As with data from any laboratory test, considerable caution must be observed in interpreting these results in terms of the performance of a particular substance under actual conditions of service. In general, such predictions should be attempted only after considerable study to establish the required correlation between laboratory data and field results. Difficulties may be expected not only in attempting to relate laboratory data to industrial installations, but even in applying experience from an existing plant to the design of a second "similar" plant.[9] However, it should be mentioned that a few critical laboratory tests, to establish the kinetic types of the fundamental corrosion processes involved, often aid greatly in making possible reasonable predictions of long-time corrosion rates.

The electrical resistance method is particularly recommended for classifying similar media (or metals) according to their *relative corrosivities* (or their *relative corrosion resistance)*. If the limitations and precautions discussed above are clearly borne in mind the resistance method can yield very useful results.

Description of the Method

Specimens—Figure 1 represents a typical specimen. The "tails" serve as "potential" and "current" leads. For measurements with plain carbon steel, it is convenient to use shim stock (0.001 to 0.005-inch thick). When specimens of fixed thickness are used, the resolution of the method is limited only by the

reproducibility of the resistance measurements. With the present apparatus, this is of the order of 0.02-0.05 percent of the original thickness. Since this represents corrosion from both sides of the strip, the practical limit in terms of penetration from one side is one-half of this. If less precision is adequate, the requirements suggested for the apparatus may be modified accordingly.

The width and the length of the specimen may vary over a wide range. The specimens can be cut with scissors or with a sharp knife; a metal-cutting stencil permits cutting several specimens simultaneously and uniformly. This uniformity of width facilitates the electrical measurements. The surface cleaning may consist of any usual chemical cleaning procedure. Abrasion is not practical, and it is doubtful if abrasion and polishing actually are necessary for obtaining useful results. The need for preannealing, as discussed previously, is determined by a blank run at the test temperature. In the present work, degreasing with solvents followed by annealing in vacuum at 1200 degrees F for one hour was found to be satisfactory for the preparation of steel specimens.

Specimen Holders—Typical specimen holders are shown in Figure 2. The specimens are held in an assembly of four parallel tubes, with the specimen "tails" (leads) each strung through a separate tube. It is convenient to fuse two double-bore quartz tubes, obtainable from commercial suppliers of fused quartzware, to provide a rigid specimen holder. The holder is used to secure the specimen both during the measurements, as described below, and in the reaction zone.

If elevated temperatures are involved, it is essential to eliminate erratic thermoelectric forces. This may be done by making the connections from the copper circuit wires to the "tails" of the specimens outside of the corroding medium and by shielding the connections symmetrically from thermal effects in order to maintain the junctions at equal temperatures. In liquid media the possibility of galvanic effects must be considered.

Measuring Circuit—The electrical resistance, or the electrical conductance, of the specimens is readily measured before and after the completion of the corrosion experiment by connecting the specimen into the circuit shown in Figure 3. This circuit may be constructed from standard parts in a few hours. The holder **A,** with the specimen, is placed in a test tube which is mounted in a commercially obtainable water thermostat **B** maintained within ± 0.05 degrees C or better, at any convenient temperature. The test tube is kept filled with some solvent, such as clean benzene, to facilitate adjustment of the specimen to the temperature of the thermostat. The ends of the specimen are connected to the measuring circuit by small alligator clips. A direct current of 0.3 to 1.0 ampere from a storage battery **C** is passed through the specimen and through a series manganin reference resistor **D** of 0.1-0.3 ohm. The reference resistor is placed in a similar test tube in the same bath, to eliminate thermal emf's from the manganin-copper junctions. A potentiometer **E** with a sensitivity of 0.01 mv may be connected by a selector switch **F** either to the resistor **D** or to the specimen.

Two measuring procedures are possible, corresponding to the determination of the conductance or resistance of the specimen. For conductance measurements, the potentiometer is connected to the specimen and the current is adjusted by means of a precision ten-turn rheostat **G** to a value which results in a convenient "standardized" potential drop across the specimen. The potentiometer is then switched to **D,** and the corresponding potential across the reference resistor is measured. This potential is directly proportional to the current through the specimen and hence directly proportional to the conductance of the specimen. After the completion of the test and while still mounted in the holder, the specimen is replaced in the thermostat, the current again adjusted to give the "standardized" potential across the specimen and the conductance measured as before.

The conductance is directly proportional to the cross-sectional area of the specimen. Since relative changes in width are very much smaller than the relative changes in thickness, a decrease in area may be assumed to be due solely to a decrease in thickness. Therefore the depth of penetration by corrosion from one side of the specimen is:

$$\text{Corrosion} = \frac{(\text{Initial Cond.} - \text{Final Cond.})}{\text{Initial Thickness}} \times \frac{\text{Initial Thickness}}{2}$$

For purposes of calculation the appropriate voltages across the reference **D** are substituted for the conductances. The initial thickness of the specimen is best obtained by weighing a measured square of the metal used.

Recording Circuit—The adaptation of the electrical method to produce a continuous record of the course of the corrosion is relatively simple; the specimen is placed in the corrosive medium and the resistance of the specimen is recorded continuously. It is essential to maintain proper temperature control, because the resistance of most metals changes by several tenths of one percent per degree C. With modern controls and with block furnaces and ovens made of aluminum or other metals it is a simple matter to maintain the temperature constant within a fraction of a degree. Thus the resolution of the continuous method, even at elevated temperatures, approaches that of the thermostat method described above. For work at atmospheric temperatures, the tests are performed in test tubes in the water thermostat itself. For work with alloys which have much lower temperature coefficients of electrical resistance than do pure metals, the temperature control may be much less elaborate.

For continuous recording, it is most convenient to maintain the current constant and to record the voltage drop across the specimen. This voltage drop is directly proportional to the resistance and inversely proportional to the cross-sectional area of the specimen. Constant current may be achieved in two

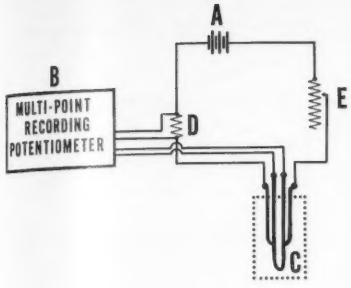

Figure 4—Continuously recording circuit. A, storage battery; B, multi-point recording potentiometer; C, specimen in the corrosive medium; D, constant resistor; E, adjustable resistor.

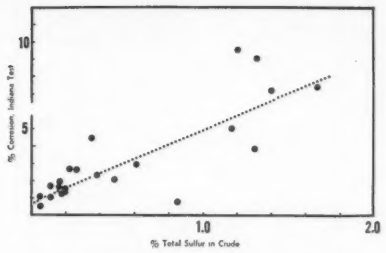

Figure 5—Relation between the corrosivities of twenty-two crude oils to steel at 800 degrees F and the total sulfur content of the oils. A = 5 percent naphthenic acid in the white oil.

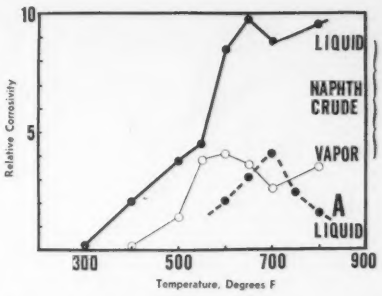

Figure 6—Corrosivity vs. temperature curves for a naphthenic base crude oil showing characteristic maximum. Curve A: liquid phase corrosion in a synthetic mixture of highly refined white oil with 5% Aruba naphthenic acids.

ways. If a high-grade electronic DC voltage source is available, a large constant resistor may be placed in series with the specimen. The current then becomes relatively independent of changes in the resistance of the specimen. In lieu of such stabilized sources, storage batteries may be used in conjunction with current-regulator tubes (commercial iron-hydrogen ballast tubes). If batteries are used without current-stabilizing devices, the reliability of the measurements may be increased by recording simultaneously the resistance of the specimen and the strength of the current and correcting for any drifting of the latter that may occur during the test.

A typical circuit is shown in Figure 4. The storage battery **A** supplies the current. The multipoint recording potentiometer records in turn the potential drop across the specimen **C** and across the constant reference resistor **D.** The potential across resistor **D** is directly proportional to the current strength. After reducing the specimen readings to the same current strength, if necessary, the depth of penetration by corrosion may be calculated thus:

$$\text{Corrosion} = \frac{R_t - R_o}{R_t} \times \frac{(\text{Initial Thickness})}{2}$$

where R_t is the potentiometer reading at time t and R_o the initial reading.* If sufficient "points" are available on the recorder, several corrosion tests can be followed simultaneously.

Typical Applications of the Method:

1. *Determination of Relative Corrosivities of Crude Oils at Refinery Temperatures*

This work was initiated by the Subcommittee on Corrosion of the Committee on Refinery Equipment of the American Petroleum Institute's Refinery Division and led to a development of a tentative relative corrosivity scale for crude oils.[10]

In the procedure generally used, low-carbon vacuum-annealed steel specimens, cut from 0.001-inch shim stock, were exposed to 100 cc samples of crude oils in a 1-inch ID, 10-inch long 18-8 stainless steel bomb. The bomb was equipped with a riser, a pressure gauge and a relief valve set at 80 psig. The bomb was held for one hour in a preheated, forced convection furnace at 800 degrees F. Approximately 35 minutes of this period was required to bring the oil up to the furnace temperature. The corrosion of the specimens, which were mounted in quartz holders, was measured as described under "Measuring Circuit." The effects of the variables—time, temperature and pressure—were investigated also.

Figure 5 illustrates the relation between the sulfur content and the corrosivities at 800 degrees F. of the twenty-two crude oils tested. It is evident that the sulfur content is not the only factor which determines the corrosivity of crude oils. Figure 6 compares the corrosivities of the liquid and the vapor phase of a naphthenic-base oil over a range of temperatures. The maximum is characteristic of the naphthenic oils and is shown also by a synthetic mixture of a highly-refined white oil containing 5 percent naphthenic acids.

The activation energy for a particular chemical reaction may be calculated from the slope of the usual Arrhenius plot (logarithm of reaction rate versus reciprocal of absolute temperature). Since only the ratios of the rates determine the slope, the ordinate may be expressed in any units proportional to the absolute corrosion rate. Such a curve is shown in Figure 7 for a relatively volatile Williston Basin crude. The low value of the activation energy, 7.5 kcal above 550 degrees F, indicates that the corrosion rate is, at least in part, controlled by diffusion through the non-turbulent layer of oil at the surface of the specimen.

2. *Identification of the Source of Corrosive Agents in a Vis-Breaker Unit Evaporator Tower*

Severe corrosion was observed on the baffles at the top of an evaporator tower of a vis-breaking unit which charges a "dirty gas oil." This feed consists of a mixture of crudes, reduced crudes and refinery

*By means of a commercially available adjustable spring ruler (e.g., Gerber Sc. Co.), the degree of corrosion expressed as percent of the original thickness may be read directly from the recorder chart.

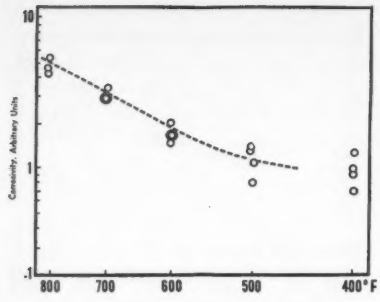

Figure 7—Arrhenius activation energy plot for corrosion of steel by a Williston Basin crude oil. Note the change in mechanism below 550 degrees F, as indicated by the change in slope.

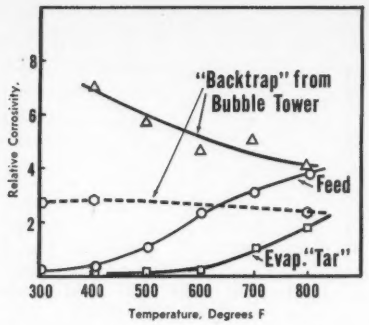

Figure 8—Liquid phase corrosivities of streams in a vis-breaking unit.

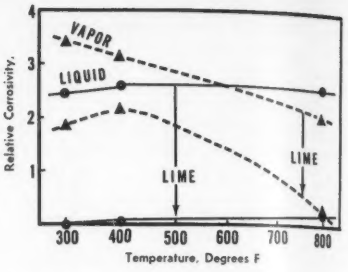

Figure 9—Influence of lime on corrosivity of "backtrap" liquid and vapor.

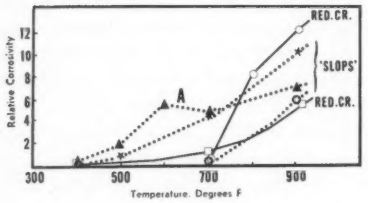

Figure 10—Corrosivity of some vis-breaker unit feed components in liquid phase. Data for two reduced crudes and three refinery "slops."

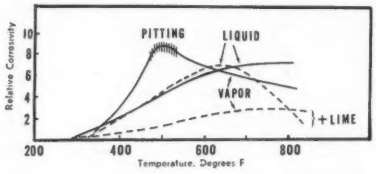

Figure 11—Influence of lime on corrosivity of the liquid and the vapor phases of a refinery "slop."

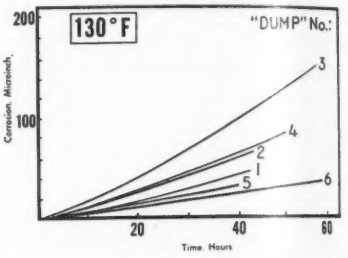

Figure 12—Corrosion of steel in sulfuric acid sludges at 130 degrees F (54 degrees C). Numbers indicate the successive acid charges ("dumps").

"slops" resulting from various refining operations. The evaporator receives its charge from a furnace through a series of soaking drums; "tar" is taken from the bottom of the evaporator, and the overhead from the evaporator is separated into gasoline and backtrap (bottoms) in a subsequent bubble tower. The temperature at the baffles is below 800 degrees F, but is not known exactly since the backtrap is recycled as a cracking quencher to the top of the evaporator tower. Lime is added to the feed to reduce its corrosivity.

Samples of oils were obtained from the unit and tested as described under "Corrosivity of Crudes," over a range of temperatures at 85 psig. Figure 8 indicates that the evaporator feed increases in corrosivity with temperature in a normal manner and that the evaporator bottoms (tar) is much less corrosive. However, the backtrap is highly corrosive. The decrease in the corrosivity with temperature is due largely to the technique used in the test; at higher temperatures the more volative corrosive compounds escape from the bomb through the pressure regulator. Thus, the source of the corrosion is the vapor phase in the evaporator, specifically that part of the vapor which subsequently condenses at the bottom of the bubble tower. The two samples of backtrap are from two similar units.

Figure 9 shows that lime additions in the laboratory test reduce the corrosivity of the backtrap liquid but the corrosive agents in the vapor escape neutralization unless the temperature approaches 800 degrees F. Consequently, lime additions to the backtrap which is recycled to the evaporator tower as reflux will react with the volatile corrosivity factors only if sufficiently high temperatures are reached in the reflux zone.

Figure 10 shows the liquid corrosivities of some of the feed components. In all cases except component A, the vapor corrosivities are less than those of the liquid. Additional data for component A are shown in Figure 11. The vapors are much more corrosive than the liquid at 400-500 degrees F, exhibiting a maximum such as was observed with naphthenic oils (see Figure 6). Lime reacts effectively with the volatile corrosive agent; the non-volatile (liquid) corrosive agents are neutralized by lime only above 600 degrees F. In this case of vapor corrosion the specimens are etched rather than covered with sulfidic corrosion products as is the case with the specimens tested in other feed components. On the basis of these findings, it was recommended that this particular component be eliminated from the feed to the unit.

3. *Determination of the Corrosivity of Sulfuric Acid Sludges*

In the refining of lubricating oil stocks, sulfuric acid is added to the oils in definite successive portions, called "dumps." The temperature of the mixture increases at the time of addition because of the heat of reaction; larger acid additions cause higher temperatures. Laboratory tests were made to establish the variation of the corrosivity of the mixtures with the number of charges of acid and with the temperature.

Steel specimens, made as described previously,

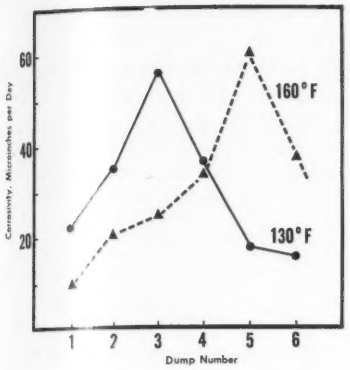

Figure 13—Variation of the corrosivity of sulfuric acid sludges to steel with "dump" number and temperature.

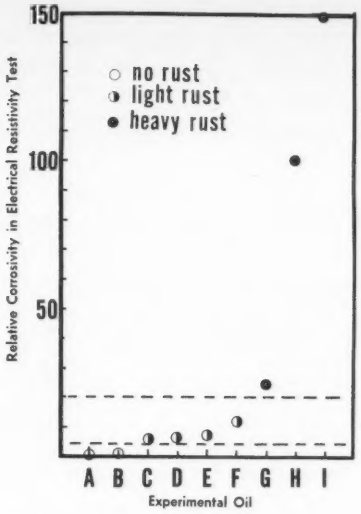

Figure 14—Comparison of the electrical resistance method with Navy Static Drop Test for a series of oil-soluble rust inhibitors.

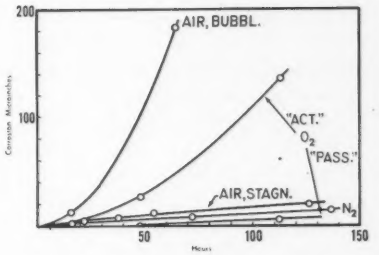

Figure 15—Corrosion of bare steel in water saturated with gases, at 90 degrees F (32 degrees C).

were immersed in samples of sludges in large test tubes kept in aluminum block ovens at the temperatures which were of interest. The resistance changes due to corrosion were recorded by a twelve-point recording potentiometer. Remarkably good agreement was obtained between duplicate samples, even though the samples of sludges appeared to be rather nonhomogeneous and evolved sulfur dioxide gas continuously. Figure 12 shows the results at 130 degrees F. The attack is linear. From Figure 13 it appears that the intermediate "dumps" produce more corrosive sludges.

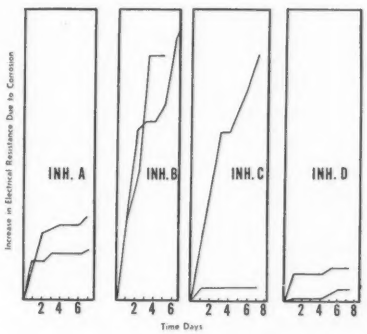

Figure 16—Reproducibility of long-term corrosion vs time curves for several oil-soluble rust inhibitors. Steel with inhibited-oil film in water, 90 degrees F.

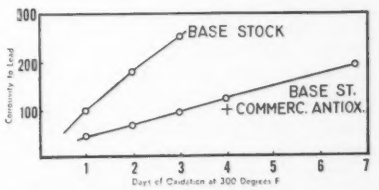

Figure 17—Change in corrosivity of lubricating oil to lead with oxidation at 300 degrees F (149 degrees C). Oxidation under rapid stirring, with copper surface present. Relative corrosivity in terms of corrosion in micro-inches in 16 hours exposure to a 50 ml sample of oil at 250 degrees F (121 degrees C), without stirring.

4. *Quantitative Assessing of Oil-Soluble Rust Inhibitors*

The Navy Static Drop Test[11] grades the effectiveness of oil-soluble rust inhibitors on the basis of a visual observation of standardized specimens. It appeared that the electrical resistance method might be adapted readily to provide a quantitative measure of the amount of inhibition obtained.

The method developed uses essentially the same type of specimen as is described in the previous sections. The steel shim stock is degreased with carbon tetrachloride and alcohol, blotted and cut (using rubber gloves). The specimens are then annealed in vacuum at 1200 degrees F for ½ hour and stored in a desiccator. This treatment yields satisfactorily clean surfaces. For testing, the specimens are first mounted in holders, immersed in the experimental oils for one hour and then drained of the excess oil. These oil-coated specimens are immersed in water or weak electolyte solutions in one-inch diameter test tubes which are mounted in the cover plate of a 15-inch diameter water thermostat. One thermostat accommodates up to 24 test tubes. Air is slowly bubbled through the test tubes in series by means of Tygon tubing. Small clips or soldering lugs mounted on the bath cover (four around each tube) serve to connect the specimens to the measuring circuit through a multiple-selector switch of a quality such as may be used with thermocouples. This permits the corrosion of each of the specimens to be followed for periods of hours and days without disturbing them mechanically.

Exposures of one-day duration were found to be sufficient for comparison of the efficiency of the inhibitors. Table 1 shows some results, on a relative basis, for corrosion in de-ionized water (representing condensate water). Figure 14 illustrates the extent of agreement between the ratings by the electrical resistance method and by the Navy Static Drop Test for a series of experimental oils.

In a preliminary study, the effect of gases on the corrosion of steel in water was investigated. Figure

TABLE 1—Relative Corrosion Rates of Steel Covered With Oils Containing 0.5% of Oil-Soluble Inhibitors.
Corrosive Medium: Aerated Deionized Water at 80 F.

OIL	Relative Corrosion Rate
Bare Steel	250
Neutral Light Distillate, Oil, No Inhibitor	100
Same, + Inhibitor A	2
Same, + Inhibitor B	4
Same, + Inhibitor C	2
Same, + Inhibitor D	8
Same, + Inhibitor E	2

15 represents typical effects. In quiescent water open to the air, and in water through which nitrogen is bubbled, the corrosion rate is low. Under these conditions it is difficult to differentiate among inhibitors according to their effectiveness. When air is bubbled through the water, rapid corrosion occurs, indicating diffusion control of the corrosion process. Bubbling oxygen reduces the corrosion rate and frequently yields results such are shown by the curve "0_2-passive." Although this apparently is a passivation effect it occurs also (though much less frequently) when air is bubbled through the water. If 20-100 ppm NaCl solution is used instead of de-ionized water, the passivation effect is less frequent.

Figure 16 represents some long-exposure duplicate runs for four inhibitors. In the case of inhibitor "C," the large variation in the performance of a pair of specimens is due to a spontaneous passivation of one specimen on the second day of the test. Spontaneous passivation also may cause difficulties in the Static Drop Test. For this reason, the maximum corrosion rate observed in duplicate runs, rather than the average of the runs, should be used in evaluating effectiveness of the inhibitors, unless this maximum rate is due to some obviously extraneous cause.

Despite the constant stirring by the bubbling air, the specimen leads encased in the holder often corrode by virtue of the establishment of oxygen cells. If the solution is sufficiently conductive, the leads may provide cathodic protection to the specimen. In case of erratic results, this possibility should be considered. This complication may be avoided by sealing the bottom of the holders with a drop of paraffin. On the other hand, highly localized attack may be the result of a contaminated surface or of injury to the film during handling.

5. *Determination of the Corrosivity of Lubricating Oils to Lead*

New lubricating oils are rarely corrosive to lead. As an oil oxidizes, however, acids and peroxides form and a corrosivity to lead develops.[12,13] This action is inhibited in practice by the use of anti-oxidants and other additives in the oils. The oxidation of lubricating oil may be evaluated in terms of various parameters, such as percent of pentane insolubles, etc. For oils which are to be used in machines with lead-copper bearings, the corrosivity to lead may serve as a criterion of the extent of oil oxidation.

As an example of an application of this kind, oils were oxidized in air in half-gallon batches by rapidly stirring at 300 degrees F, in stainless steel containers, in the presence of copper catalyst (1 cm^2 copper surface per 1 cm^3 of oil). This was a rather drastic oxidation. Samples of the oils (50 cc) were withdrawn from the oxidizing apparatus after definite time intervals and replaced by a like amount of fresh oil. The oxidized oil samples were tested for their corrosivity by immersing in them lead specimens cut from 0.002-inch foil. The tests were made in test tubes placed in holes in an aluminum block thermostatted at 250 degrees F. This temperature is representative of rather high bearing temperatures. Overnight exposures (16 hours) were sufficient to produce readily measurable amounts of corrosion by the oils which had deteriorated. Figure 17 compares the increase, with oxidation, of the "relative corrosivities" of a plain base stock and of the same base stock containing a common anti-oxidant additive.

Acknowledgment

Assistance of Messrs. C. H. Samans, R. S. Neymark, R. S. Cheney, R. J. Hafsten, A. A. Anderson and Miss Cecelia Husen in the various phases of work is gratefully acknowledged.

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NACE News

Portland Ore., Ohio Valley Sections Organized

SOME OF THOSE WHO TOURED THE LOCKHEED plant at Marietta, Ga., during the May 6 Spring Meeting of Southeast Region NACE.

TECHNICAL PROGRAM SPEAKERS at joint Miami-Jacksonville Section Meeting at Miami May 14 are, left to right: T. P. May, the International Nickel Co., Inc., New York; Burke Douglas, Dow Chemical Company and Ed Doremus, Cathodic Protection Service, Houston.

ROY E. JONES, executive vice-president, Peoples Water and Gas Company, dinner speaker at the joint Miami-Jacksonville Section meeting May 14.

Joint Meeting Held by Miami and Jacksonville

Three technical talks featured the joint Miami-Jacksonville Section meeting May 14 at McAllister Hotel, Miami. T. P. May, International Nickel Co.,

(Continued on Page 2)

Southeast Region's Fall Meeting Is November 4-5

Jacksonville, Fla. will be the site of the November 4-5 fall meeting of Southeast Region. Arthur B. Smith, Amercoat Corp., Jacksonville is program chairman.

A smorgasbord will be given at the beach November 4.

Officers Are Named For 42nd, 43rd NACE Sections During May

The 42nd and 43rd sections of the National Association of Corrosion Engineers were organized in Portland, Oregon and Louisville, Ky. during May. Both sections have named officers and the Portland Section scheduled a second meeting June 1.

Officers of Portland Section have been named as follows: Charles E. Haney, Electric Steel Foundry Co., chairman; P. G. Behr, Portland Gas & Coke Co., vice-chairman and B. Neally Wood, Charlton Laboratories, Inc., secretary-treasurer, all of Portland. The June 1 meeting included a talk by H. O. Teeple of The International Nickel Co., Inc., New York on Corrosion Problems in the Pulp and Paper Industry.

Temporary officers were named as follows following a May 12 meeting at Louisville, Ky. of the Ohio Valley Section: Lewis P. Aker, Louisville Gas and Electric Co., chairman; Charles Maddux, Southern Bell Telephone and Telegraph Co., vice-chairman and Richard F. Hafer, Reynolds Metals Co., secretary, all of Louisville.

At the June 1 meeting of the Portland Section H. O. Teeple of the International Nickel Company spoke on Corrosion in the Pulp and Paper Industry. After first discussing the various types of corrosion encountered in pulp and paper processes, Mr. Teeple discussed some of the results of a current TAPPI study on alkaline digester corrosion. This specific example was used to illustrate the step by step approach to the solution of a complex corrosion problem. The statistical analyses made in the study were illustrated by slides.

HALF-YEAR MEMBERSHIPS IN NACE

Applications for active membership in the National Association of Corrosion Engineers received at the Central Office after July 1st, may, at the option of the applicant, be for the last half of the calendar year—July-December inclusive, with dues of $5.00.

- **This half-year membership entitles the member to receive copies of CORROSION magazine for the months of July-December, inclusive and all the benefits of the association after July 1.**
- **If you are interested in membership in NACE write for an application for membership or see the NACE Section secretary if an NACE section operates in your city.**
- **Applications for membership for the whole of the calendar year will be accepted also and copies of CORROSION supplied for the whole year as long as the supply of back issues lasts.**

Write to A. B. Campbell, Executive Secretary NATIONAL ASSOCIATION OF CORROSION ENGINEERS, 1061 M & M Bldg., Houston 2, Texas.

CLEANING, COATING, WRAPPING & RECONDITIONING

★

HOT DOPE

Straight from the Kettle on PIPE PROTECTION

★

By Boyd Mayes

Got strung out in a confab with a friend the other day about saving money. Saving's an interesting subject to us, because that's our business since our job is saving pipe by giving it the "forever" treatment before it goes in the ground. An old darkey named Uncle George Washington Jones up in the Piney Woods used to have a funny slant on saving. He lived in a tumbled down shack and raised corn for a living. He had a hound dog, a shotgun, a good disposition and a wide reputation for shooting crows. But he didn't call it that. He called it his *savings bank*. He figured each crow ate a hundred dollars worth of corn in a season, and lived to eat ten seasons of his corn if let be. So, every time he shot a crow he marked up a one thousand dollar "deposit" on his rickety shed. No telling what Uncle George Washington Jones' balance was last time we heard of him, but he must have considered himself pretty rich. Maybe the old fellow had something. Come to think of it, if we had all the money we'd saved the pipe line industry by *putting permanence in pipe* that moves crude oil, natural gas, and finished products from here to there we'd make Uncle George Washington Jones look like a crop failure.

MAYES BROS.

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GUEST SPEAKER AND OFFICERS of Baltimore Section are shown at the section's May 11 meeting at Park Plaza Hotel. Left to right are: Paul Ffield, director of research and development, Shipbuilding Division, Bethlehem Steel Corp.; Allen L. Alexander, Naval Research Laboratory, Washington, D. C., section chairman; George Best, Mutual Chemical Company, Northeast Region director; John L. Oliveira, Bethlehem Sparrows Point Shipyard, Inc., vice-chairman.

Howald Installed As Cleveland Chairman

Thomas S. Howald, Chase Brass and Copper Co. was installed as chairman of Cleveland Section May 18 at a meeting at Hotel Allerton, Cleveland. Other officers installed at the same time were Robert C. Weast, Case Institute of Technology, vice-chairman; Lawrence H. Schwalm, Ohio Bell Telephone Co., secretary-treasurer.

Earl A. Erich, Atlas Mineral Products Co., Mertztown, Pa. chairman of the Lehigh Valley Section spoke on Plastic Materials of Construction. He dealt chiefly with rigid polyvinyl chloride, reviewing its use in Europe before World War II and development work since in this country. Fabricating properties and the wide range of uses to which it is being put were explained and illustrated with colored slides.

Paul A. Friedrich, Iron Fireman Co., Cleveland described plans of Cleveland Engineering Society for the construction of a $1,400,000 Cleveland Engineering Center for the use of engineering and technical groups. Members of the Cleveland Technical Society's Council are cooperating with the society in disseminating information about the project.

On April 20, 1954, F. L. LaQue of the International Nickel Co., Inc., New York City, addressed Cleveland Section on Some Apparent Anomalies of Corrosion at the Hotel Allerton, Cleveland. His address was illustrated with slides. A discussion followed.

At the same meeting results of the annual election of officers of Cleveland Section were announced. Officers are T. S. Howald of Chase Brass and Copper Co., chairman; R. C. Weast of Case Institute of Technology, vice-chairman and L. H. Schwalm of Ohio Bell Telephone Co., secretary-treasurer. They were installed at the May meeting of Cleveland Section.

•

Members of NACE may run a Positions Wanted classified advertisement annually in two consecutive issues of Corrosion without charge.

Baltimore Section Hears Talk by Paul Ffield

The last meeting of the spring season of Baltimore Section was held at Park Plaza Hotel, May 11, during which a paper was presented by Paul Ffield, entitled: A Shipbuilder Looks at Corrosion. Eighty-five members and guests were present.

The large attendance was attributed in part to the growing interest in the Baltimore area in ship corrosion because of the concentration of shipbuilding and repair industry in the area.

1958 Conference Dates Set

A committment has been made for hold the 1958 Fourteenth Annual Conference and Exhibition of the National Association of Corrosion Engineers in San Francisco March 17-21, 1958.

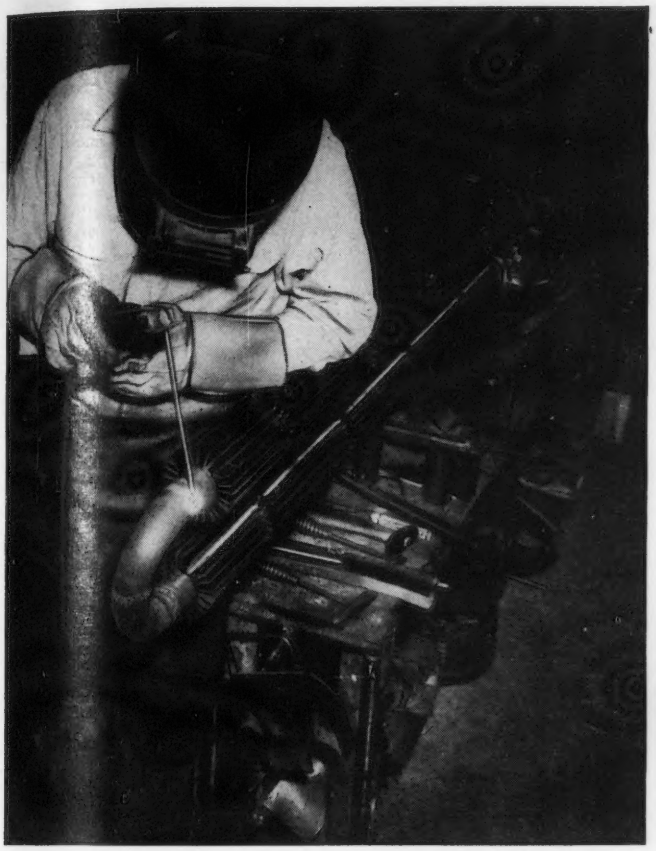
Joint Meeting—

(Continued From Page 1)

Inc., spoke on the fundamentals of corrosion and illustrated his discussion with slides and samples of actual corrosion. Ed Doremus of Cathodic Protection Service, Houston, explained cathodic protection of sea water illustrating his talk with slides showing installations on pipelines, offshore rigs and ship hulls. Burke Douglas of Dow Chemical Company outlined methods used in the manufacture of magnesium anodes and with the aid of motion pictures showed how anodes are used to protect steel piling and sea walls. A discussion followed the talks.

Manufacturers' representatives had display tables set up near the registration desk and refreshments were served through their cooperation. Wives of members attended the fellowship hour and the dinner following. Joe Frink, vice-chairman of Miami section introduced the after-dinner speaker Roy E. Jones, executive vice-president, Peoples Water and Gas Company, whose subject was "Human Corrosion Control."

Corrosion can be controlled



COOLING HOT CHLORIDES

Because of its unusual design, this heat exchanger has two to eight times the heat-transfer of plain bare pipe or tubing. HASTELLOY alloy B gives the assembly the necessary corrosion resistance. The exchanger, which was formed from alloy B strip, pipe, and elbows, handles hot chloride-bearing chemicals.

PREPARING PROTECTION

A HASTELLOY alloy C safety valve similar to the one being lapped here was inspected recently after handling 500 "pop" reliefs of scalding acid vapors. It was found that the alloy surface still had its original polished finish.

HASTELLOY *alloys can help solve your corrosion problems, too. For further information, contact the nearest Haynes Stellite Company office listed below.*

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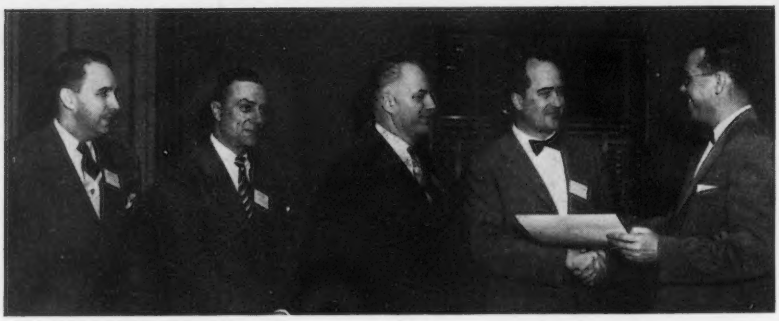

PHILADELPHIA SECTION past presidents are shown here receiving service scrolls from George Best (right) at a May 14 meeting. From left to right others in the photograph are: Edward G. Brink, W. Ronald Briggs, Robert R. Pierce and Hugh H. Hamilton. Henry F. McConomy, one of the past presidents, was not present when the photograph was taken.

Metallizing Discussed by Meyer at Oklahoma City

Members of the Central Oklahoma Section attending the May 25th dinner meeting heard Mr. Walter B. Meyer of the St. Louis Metallizing Company present a very informative talk and saw slides covering the metallizing process of his company and the application of plastics over the sprayed metal coatings. The meeting was held at the Oklahoma City YWCA.

This was the last regularly scheduled meeting for the summer. Next meeting is scheduled September 28.

Niagara Frontier Section Officers Are Named

The following officers were elected at a May 26 meeting of Niagara Frontier Section: William R. Wardrop, Metal-Cladding, Inc., Buffalo, chairman; Wade Wolf, Grand Island, N. Y., vice-chairman; J. M. Fouts, Buffalo, secretary-treasurer.

This meeting was the last of the current season. During late September or early October a meeting will be held featuring a discussion of corrosion of underground structures.

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BART LECTRO-CLAD NICKEL-PLATED Steel Plate and Sheet

for fabricating into products demanding corrosion and contamination control.

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★ THICKNESS OF CLADDING can be supplied to particular requirements and not necessarily governed by the thickness of the steel plate over which it is applied.

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★ LECTRO-CLAD Plates and Sheets withstand heating, forming, bending and other fabricating processes without change.

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LECTRO-CLAD PLATE is the direct outgrowth of the successful patented BART PROCESS for nickel-lining of seamless steel pipe and fittings.

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St. Louis Section Installs Officers, Hears Weisert Talk on High Alloys

Installation of officers for 1954-55 was the principal business conducted at the last meeting of the year of the Greater St. Louis Section held at the York Hotel, St. Louis, May 10. Technical speaker was Edward D. Weisert, Haynes Stellite Co., Kokomo, Ind.

Newly installed officers are: William J. Ries, Tretolite Co., chairman; Robert D. Sanford, Nooter Corp., vice chairman, all of St. Louis; George T. Shutt, Shutt Process Equipment Co., Kirkwood, Mo., secretary and Donald H. Becker, Reilly Tar and Chemical Corp., Granite City, Ill., treasurer.

In his talk, Mr. Weisert said that the use of high alloy corrosion resistant materials has been a definite trend in the past few years. The nickel alloys have proven excellent for corrosion-resistant service, he stated. He discussed some of the general problems in materials selection for corrosion-resistant service. The family of nickel-base alloys was described according to the types of service in which they are used. The speaker also traced the historical development of nickel-molybdenum, nickel-molybdenum-chromium and nickel-silicon alloys, as well as their properties and use. Mr. Weisert's articles on the corrosion-resistant properties of Hastelloy alloys have appeared in Chemical Engineering and Corrosion magazines. He is a member of NACE and ASM.

Teeple Is Guest Speaker At Vancouver Meeting

H. O. Teeple of the International Nickel Company was guest speaker on Corrosion and Corrosion Engineers at the Vancouver Section meeting scheduled June 11 at McGavin's Auditorium, Vancouver. This was the last meeting of the current season for the Vancouver Section.

Kenneth L. Scollay, of the Atlas Mineral Products Company, died April 16. Mr. Scollay, a member of the NACE since 1952, received a bachelor's degree in mechanical engineering at the University of Wisconsin. He also was a member of the Association of Military Engineers.

Oliver C. Klinger, Sr.

Oliver C. Klinger, Sr., publisher of *Pipe Line News, The Pipeliner*, and president of the Oildom Publishing Company of Bayonne, New Jersey and Houston, Texas, passed away in his sleep April 23, 1954, in the home of his son, Oliver C. Klinger, Jr., in Westfield, New Jersey. Mr. Klinger, who had been a member of NACE since 1944, was instrumental in the publication of the registration list of the first several annual NACE conventions. In addition to the NACE, Mr. Klinger was a member of the 25-Year Club of the Petroleum Industry, The Oil Heat Institute of America, Old Timers Club of the Oil Heating Industry and Association of Petroleum Writers.

Ivanso Is Elected Chairman at Detroit

The following officers have been elected to take office in the Detroit Section effective July 1 for the 1954-55 season: E. V. Ivanso, of the Detroit Testing Laboratory, chairman; Norman A. Kerstein, of the Detroit Edison Co., vice chairman; David L. Hill, of Timken Div., Rockwell Spring & Axle Co., treasurer and R. P. Marshall, of Saran Protective Coatings, secretary.

Corpus Christi Section

At the May 25 meeting of the Corpus Christi Section Mr. Dill of Reynolds Metals Company presented an enlightening talk on the uses of aluminum and made some remarks on the "Shape of Things to Come," which included many of the new designs and various aluminum alloy materials and their ultimate uses. The section scheduled its next meeting for June 22 at the Nueces Hotel.

Plans for September Made By Los Angeles Section

Tentative plans for its September meeting have been made by Los Angeles Section. John F. Mason, Jr., The International Nickel Co., Corrosion Engineering Section, New York, has been invited to speak on The Interpretation of Corrosion Test Results. In other action, the Section scheduled a membership vote on changing section by-laws during June.

At the June 12 meeting, members heard two technical speakers discuss oil well corrosion. R. J. Hull, senior engineer in charge of natural gasoline and corrosion research, California Research Corp., La Habra, Cal. spoke on Corrosion as Affected by Fluid Flow. Mr. Hull covered the stepwise development of laboratory data, revealing the problem of corrosion pitting about the pin and box section of sucker rods. Field tests were then made to confirm laboratory results. These tests established that fluid flow turbulence about the pin and box section of the sucker rods resulted in characteristic pitting corrosion.

This investigation led to the design of a streamlined pin and box sucker rod. Illustrated slide pictures highlighted the field service results of the experimental, streamlined rod sections, focusing attention on the improvement in corrosion resistance when compared with the performance of standard rod sections under the same conditions. A model of the new design sucker rod pin and box section was shown to the group.

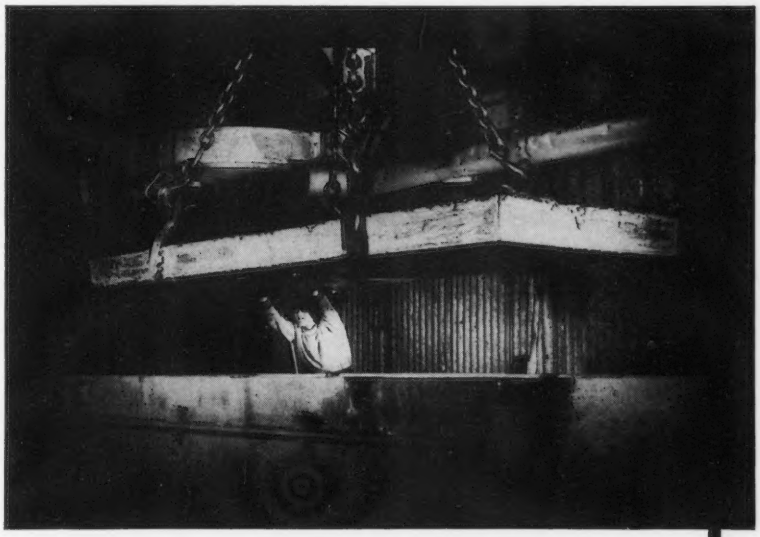
The second speaker, Frank E. Davie of Shell Oil Co., Los Angeles, Cal., reported on the Survey of Corrosion Control in California Pumping Wells. This survey was compiled by Mr. Davie and Preston Hill, of the Signal Oil and Gas Co., Los Angeles, Cal., from data furnished by members of an NACE T-1 Committee, covering 350 oil wells in California. This discussion was a review of the paper presented by Mr. Davie at the 10th Annual NACE Conference in Kansas City.

Mr. Davie described the unique punch card system used to gather information, which reduced the time for the operator in filing the will information and yet saved time in recording and analysis of the survey results.

The corrosion survey was primarily concerned with the effect of using corrosion inhibitors in California pumping wells. Mr. Davie related that 65 percent of the corrosion inhibitors included in the survey were the inorganic type (mainly arsenite and chromates), 35 percent organic type inhibitors. No significant difference in effectiveness was apparent between the two classes of inhibitors. Average cost of inhibitor treatment was approximately one dollar a day, including material used and labor for injecting the chemical.

Summarizing the results of using inhibitors in California oil wells, Mr. Davie used slides to point up the direct and indirect comparisons with untreated wells:

1. Well pulling frequencies reduced about 50 percent for the average well.
2. Total well pulling jobs reduced from 8.6 per year to 4.4.
3. Indirect savings included the reduction in labor cost for rod and miscellaneous jobs averaging about $100 each and tubing jobs at $200 each, making a labor saving of $300 per well per year.
4. Other indirect savings include less material replacements resulting in savings in maintenance cost and reduction in down time representing additional income to the operator.



Subject: lead sheet and pipe

You may say that lead pipe and lead sheet are pretty much alike no matter who makes them or from whom you buy them. "Pretty much alike" is right. But not exactly alike. Here's why . . .

Federated's experience in lead production and in lead research means that you profit two ways when you buy corrosion-resisting lead pipe, sheet, valves or fittings from Federated: You get a product that is *certain* to be as good as any other . . . and probably better . . . *and* you get the *best technical help* with your problem.

For any information on the use of lead, write to Federated's *Corrosion Advisory Service.* Address the main office (below) or any one of Federated's 14 plants and 24 sales offices across the nation.

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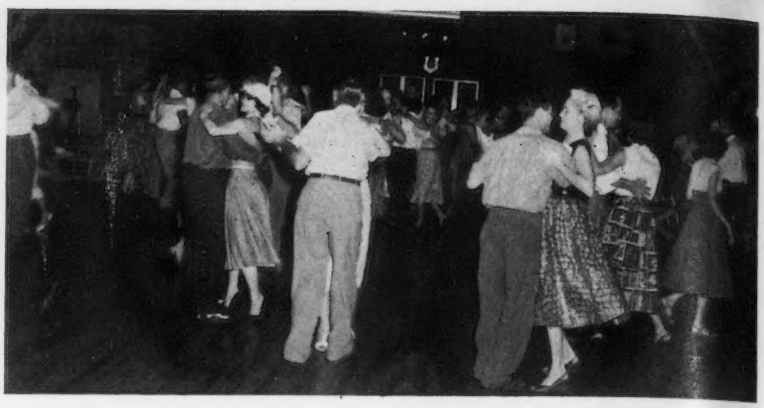
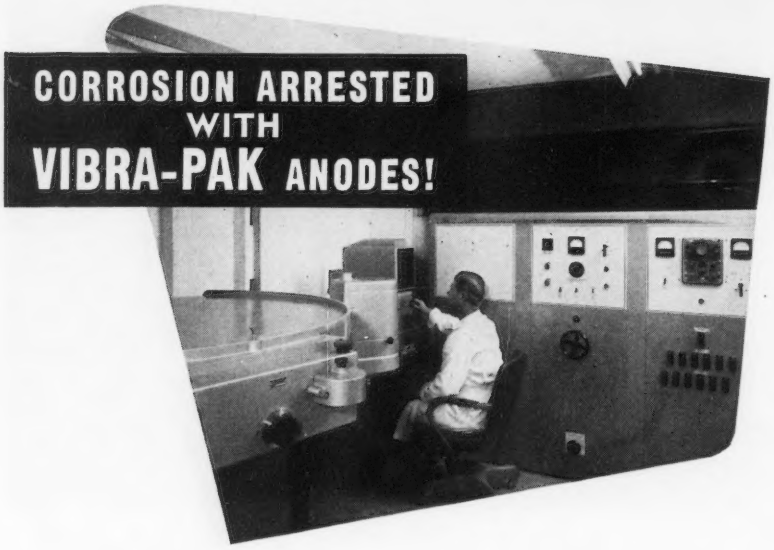
New Bibliographic Survey Volume Is Completed

The 1948-49 Bibliographic Survey of Corrosion, in print for about six months, will be available for distribution about June 15, according to information from the printers in Atlanta. The book, which will contain some 3400 abstracts, indexed according to the NACE Abstract Filing System, has 320 pages 8½ x 11 inches. It has both topical and author indexes and is extensively cross-indexed.

This volume, the third in the series of bibliographies published by the National Association of Corrosion Engineers, will be followed by the 1950-51 volume, now in preparation, sometime during 1955.



DANCERS at Diamond Alkali's recreation hall during the Houston Section's June meeting.



A major pipeline company corrosion engineer gives this authentic case history of how, after using many different corrosion control practices, he switched to VIBRA-PAK anodes with these results!

"Endeavoring to find an anode which would give us maximum efficiency and longer life, we tried Standard Magnesium Corporation cylindrical anodes and found they returned more current per pound of *magnesium and received more life per anode.*

I'm sold on Vibra-Pak high purity magnesium anodes, made to spectrographic analysis."

—VIBRA-PAK anodes are spectrographically analyzed for metal purity . . *your guarantee of longer service life!*

—a new, patented spiral core won't separate from anode . . . *positive contact is assured!*

—and remember, VIBRA-PAK means the anode is compacted and centered in the backfill through shipping, handling and placing it in the hole.

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Thornton Will Talk on Plastic Pipe at Houston Section Meeting Aug. 10

Newly elected Houston Section officers have scheduled a meeting August 10 to hear W. M. Thornton give a report of the work of Technical Committee T-1J. As chairman of the committee, Mr. Thornton has been active in conducting laboratory tests of structural plastics for oil field use and is the author of a report on laboratory testing of plastic tubular gods which appears in the Technical Committee News Section of the June issue of CORROSION magazine. The meeting will be held at Kelley's dining room, 910 Texas Avenue. Fellowship hour will start at 6 pm, with the dinner at seven and the technical meeting after dinner.

Plenty of barbecued chicken prepared on the grounds, swimming and dancing in a "country club" atmosphere was enjoyed by 144 persons at the Houston Section June picnic meeting. The picnic was held at the Diamond Alkali plant's fine recreation grounds near Houston. The only thing resembling a technical program was a conducted tour of the Diamond Alkali plant. The plant manufactures caustic soda, chlorine gas and also makes polyvinyl chloride. Drums for shipping solid as well as flake caustic are fabricated at the plant.

John Weis, corrosion engineer, showed his fellow NACE members through the plant. According to NACE member Maurice Sullender, plant engineer, a major corrosion problem is presented by the use of Houston ship channel water for cooling water. The water is more than usually corrosive and varies greatly due to seasonal changes, Mr. Sullender said. Corrosion of heat exchangers is combated by frequent cleanings, by using synthetic materials for lining exchanger tubes and by using bimetal duplex tubes with interiors suitable for withstanding corrosion of the cooling water and exteriors designed for handling the chemical.

Paint used throughout the plant serves a twofold purpose—corrosion prevention and decoration. Use of a variety of pastel colors presents a pleasing appearance to personnel.

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Permian Basin Section Will Hear Hackerman

Norman Hackerman, of the University of Texas, will be the speaker for the July 12 meeting of the Permian Basin Section. At the August 9 meeting, Permian Basin Section members will meet jointly with the AIME and TSPE. A panel discussion on water flooding will be held.

Scheduled for June was a social meeting with a barbecue, dance, bingo and other games.

At the May meeting, section members heard H. L. Bilhartz, South Central Regional chairman, speak on What Is Going on in the NACE. Purpose of the meeting was to explain the workings of the national organization of NACE and to show members how they and their companies can profit by more extensive participation in regional and national activities of NACE. In addition to this, Mr. Bilhartz delivered a technical talk Corrosion in Oil Production. As a further demonstration of how individuals and their companies can profit from NACE membership, Mr. Bilhartz used his technical subject to show the workings of NACE. His illustrations were taken directly from oil and gas production committee efforts.

New Orleans-Baton Rouge Section Elects F. S. Bird

Frank S. Bird, The California Company, has been elected chairman of the New Orleans-Baton Rouge Section for the coming year. M. R. Matherne, Southern Bell Telephone & Telegraph Co., was elected vice-chairman; Clifford L. Barr, Shell Oil Co., secretary treasurer and Henry Allen, Allen Cathodic Protection Co., trustee.

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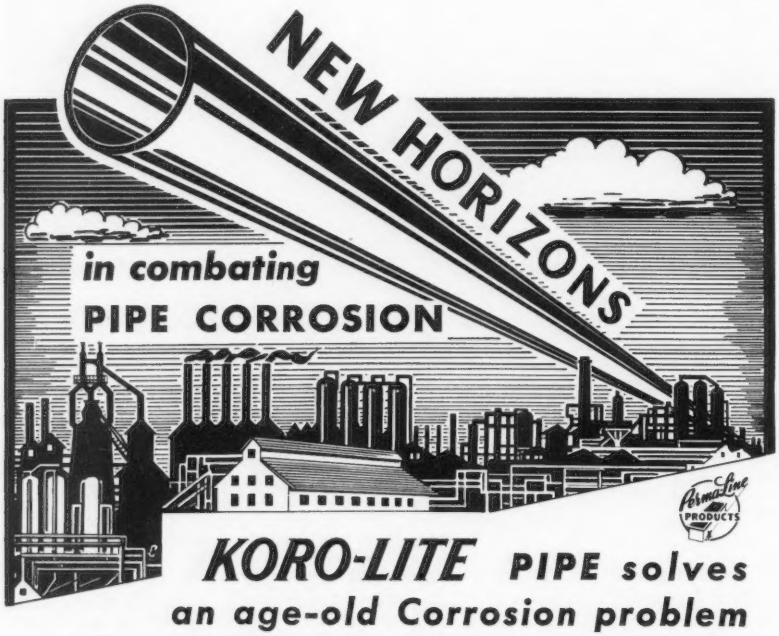
All papers presented at annual meetings of NACE, except those not approved by the association's editorial review committee and Corrosion's editor, are published in Corrosion.



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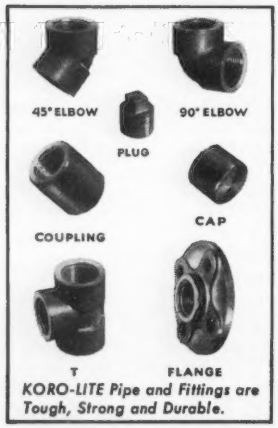

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J. Dwight Bird Is Elected Boston Section Chairman

The final meeting on May 5 for the Greater Boston Section of the 1953-1954 season was highlighted by the election of officers for the 1954-1955 season at Hotel Baconsfield, Brookline.

J. Dwight Bird, of the Dampney Company, was elected chairman; Murray M. Jacobson, of the Watertown Arsenal Laboratories, was elected vice chairman and Edward C. Rue, of the Boston Edison Company, secretary treasurer.

The fifty-five members and guests present heard a discussion by A. R. Corlett, of the Harco Corporation, Cleveland, on Cathodic Protection.

It was announced that the first meeting of the 1954-1955 season will be in October.

All Southwestern Ohio Section Members Urged To Be on Technical Groups

To increase members' knowledge concerning corrosion and to make the knowledge available to all section members, the Southwestern Ohio Section is instituting a new program. All members are urged to serve on technical committees and at each meeting various persons from the committees will make short reports on new methods and discoveries in their field.

Scheduled for the final meeting of the year, May 29, at Shullers Restaurant, Cincinnati was a talk and discussion of Cathodic Protection by R. L. Featherly of the Dow Company.

The Southwestern Ohio Section held its 5th meeting of the 1953-54 season, April 27. Chester A. Allen conducted an inspection trip through the Hilton-Davis Chemical Company, with emphasis placed on its corrosion problems. At the meeting following the inspection trip, the following officers were announced for the coming year: Walter Luce, Duriron Company, chairman; Alfred Jenss, Ampco Metal, Inc., vice chairman and program director; L. M. Lederer, Inter-Tank Lining Corp., secretary and R. L. Wood, Cincinnati Gas & Electric Co., treasurer, after which time Harold F. Borger of Hilton-Davis, spoke of the problems and tentative solutions to their dye processing batch plant difficulties.

Hunter Heads Symposium

J. N. Hunter, Jr., Service Pipe Line Company, Tulsa, Okla., has accepted chairmanship of the Pipe Line Corrosion Symposium at the 1955 Chicago Eleventh Annual Conference and Exhibition of the National Association of Corrosion Engineers.

1954 YEARBOOK

The NACE 1954 Yearbook, which will contain the directory of membership, directory of technical practices committees, Articles of Organization and By-Laws of NACE and a short history of the association will be mailed to NACE members about July 15. Additional copies are available at $2 each, postpaid.

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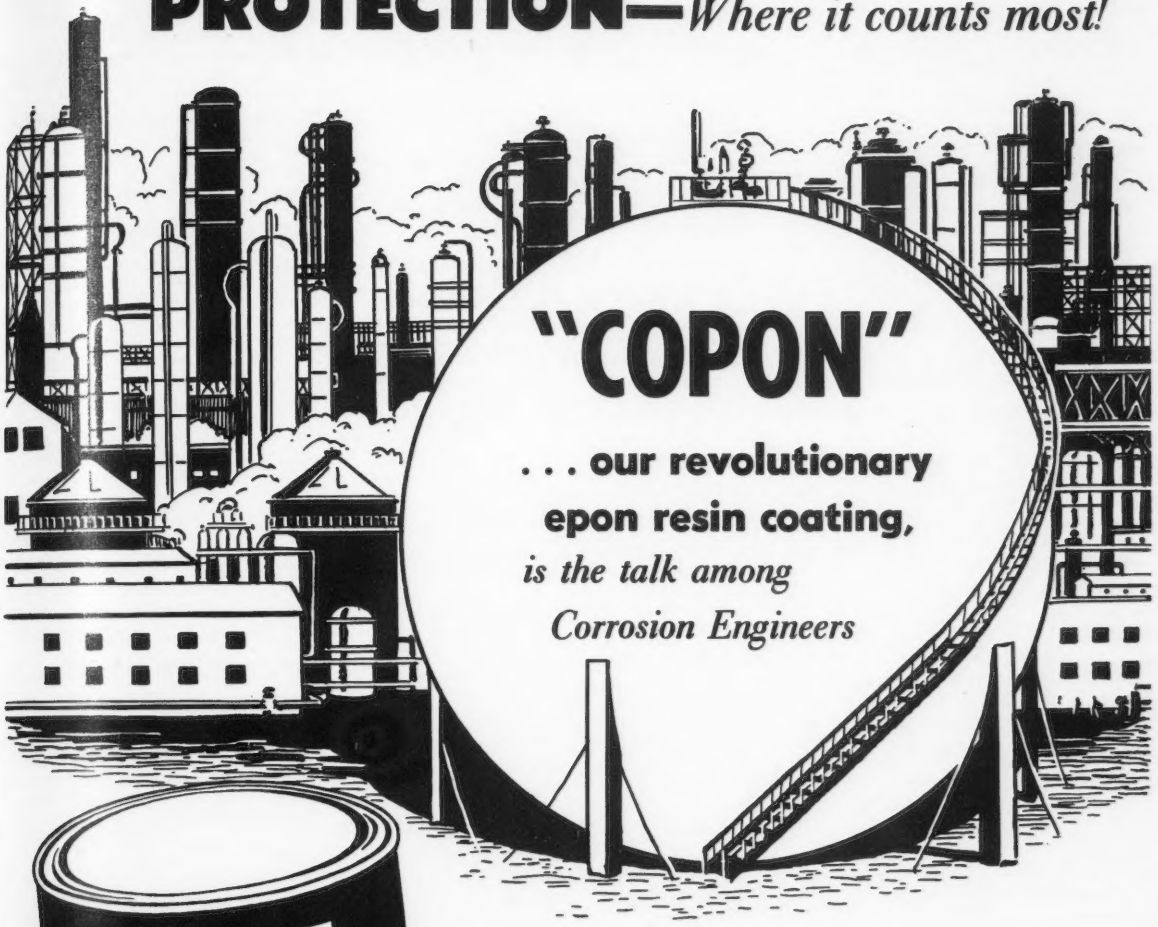

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Sabine-Neches Section Elects New Officers

Election of new officers of the Sabine-Neches Section was the sole item of business conducted at the meeting held at McFaddins Beach near Sabine Pass, May 22. After the election, 35 members and guests enjoyed an outing.

Officers elected to take office in October were: R. P. Clarke, Atlantic Refining Co., Port Arthur, chairman; Mack Abraham, Cities Service Refining Corp. Butadiene Plant, Lake Charles, vice chairman; Lee T. Dodson, Metal Goods Corp., Beaumont, secretary-treasurer and Charles E. Huddleston, Jr., Socony Paint Products Co., Beaumont, trustee.

After electing officers, members and guests devoted themselves to "having fun." There was fishing, seining, swimming and "just relaxing" climaxed by a fish and shrimp fry. Suppliers of the section donated food and beverages.

Lindberg Is Elected Chicago Section Chairman

The final dinner meeting of the Chicago Section for the current season was held May 18, at which the following officers were elected for the forthcoming year: R. I. Lindberg, Sinclair Research Labs., Inc., Harvey, Ill., chairman; R. W. Flournoy, Corn Products Refining Company, Chemical Division, Argo, Ill., vice-chairman; R. S. Wise, National Aluminate Corporation, Chicago, Ill., secretary; R. B. Janota, Swift & Company, Chicago, Ill., treasurer.

L. W. Ewing, Jr. was presented an NACE lapel pin for his accomplishments as chairman during the past year. The technical portion of the meeting consisted of an informal round table conducted by C. A. VanNatta, past chairman of the Chicago Section. Questions covered a wide range of corrosion activity including chemical storage, food processing, utilities, maintenance, cathodic protection and coatings.

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BOOK REVIEWS

The Sulphur Data Book. 143 pages, 6 x 9, cloth. 1954. McGraw-Hill Book Company, Inc., New York. Per copy, $5.00.

This is a compilation of data on sulfur by the technical staff of Freeport Sulphur Company, edited by William N. Tuller, Superintendent of Laboratories, Louisiana Division, Freeport Sulphur Co., Port Sulphur, La. The chapters are headed: The Nature of Sulphur; Physical and Chemical Properties; Reaction Thermodynamics; Solubility; and Analysis.

The book is replete with tables and graphs of data and include extensive sulfuric acid conversion tables as well as a topical index and bibliography.

Progress Report on Cathodic Corrosion of Lead. Cathodic Protection Project Report No. 5b. 8½ x 11 inches, loose-leaf. May 1, 1954. Electrical Engineering Res. Lab., Eng. Exp. Sta., University of Ill., Urbana. Free.

First part of this report is concerned with efforts at the University of Illinois Laboratories to duplicate the findings of Salzberg in 1953 as to magnitude of loss from lead exposed to acid and alkaline corrosive environments. His experiments were not reproducible as far as magnitude of weight loss is concerned. Recognizing that weight loss determinations are awkward and inconclusive, future efforts to determine the extent of attacks in these environments will be by potential decay and polarographic methods.

Second part of the report deals with experiments being set up to study cathodic corrosion of lead by batteries of lead-soil cells. Pilot tests indicate cathodic corrosion is insignificant except at very high current densities beyond the range normally found in the field. Future tests will involve densities of 3000 ma/sq. ft. downward.

Progress Report on Hydrogen Embrittlement Research. Cathodic Protection Project, Report No. 7a. 8½ x 11 inches, loose-leaf. Jan. 15, 1954. Electrical Engineering Research Lab., Eng. Exp. Sta., University of Illinois, Urbana. Free.

The report concerns progress to date of the work underway to determine the extent to which atomic hydrogen formed by normal electrolytic action at cathodically protected steel surfaces in soils and solutions diffuses into the basis metal and to determine the extent of any change or weakening of the mechanical properties of the steel. The investigations are in the preliminary stage with initial aim to determine the amounts of atomic hydrogen available for entry into the metal surface. There is some reason to believe the catastrophic brittle fractures of steel structures reported in several industries may have been due in part to adsorbed hydrogen.

Copper. The Science and Technology of the Metal, Its Alloys and Compounds. Allison Butts, editor. 6 x 9 inches, 936 pages, cloth. 1954. Reinhold Publishing Corp., New York.

One of the American Chemical Society's Monograph Series. Forty-six chapters, each written by a specialist in the subject covered in the chapter comprise this book, designed to be comprehensive and cover copper both as a chemical element and as an industrial metal. This volume covers copper from the characteristics of the ores in which it is found and continues through all principal aspects, including isotopes of copper, copper as an agricultural fungicide and most aspects of its smelting, fabrication and compounding with other materials. Each of the chapters is accompanied by pertinent references.

The subject index includes 19 references to various aspects of the corrosion of copper from acid solutions to water pipes.

There is also a name index including persons, companies and trade and technical organizations.

Chapter 18 headed "Chemical Properties and Corrosion Resistance of Copper and Copper Alloys" is by P. T. Gilbert, head of the Corrosion Section, British Non-Ferrous Metals Research Association, London. The author successively considers copper's reactions to neutral and alkaline solutions, various chemicals, sea water (with several types of attack itemized), condenser tube corrosion, fresh waters, atmosphere, soils.

(Continued on Page 11)

SHORT COURSE CALENDAR

1954

June 21-26—Massachusetts Institute of Technology, Cambridge.

1955

Feb. 2-4—University of Toronto, Hart House Theater, Toronto.

Feb. 16-18—Tulsa Section, Sixth Annual Short Course. Mayo Hotel, Tulsa, Okla.

Fall—Washington University, St. Louis, Missouri.

University of Toronto Course Set February 2-4

University of Toronto has scheduled a short course of corrosion February 2-4 inclusive at Hart House Theater. Emphasis will be on fundamentals, including some theory and economic factors. University lecturers will participate in the program one hour a day.

T. R. B. Watson, Corrosion Service Ltd., and chairman of Toronto Section has been named chairman of an arrangements committee. Committeemen include Aleck H. Carr, Koppers Products, Ltd., Toronto; Ralph E. Kuster, Union Gas Co. of Canada, Ltd., Chatham; Heard W. Hyslop, United Gas and Fuel Co. of Hamilton, Ltd., Hamilton and R. J. Law, The International Nickel Co. of Canada, Ltd., Toronto.

BOOK REVIEWS

(Continued From Page 10)

Also covered are stress corrosion, stress corrosion of brasses and other copper alloys, oxidation and scaling, electrode potential relationships, and others.

•

International Review of Metal Finishing. Edited by I. S. Hallows. 5½ x 8¾ inches, 171 pages. 1954. Sawell Publications, Ltd., 4 Ludgate Circus, London E. C. 4, England. Per copy, 10s/6d

Authors from Britain, France, Canada, Finland, Germany, Holland, India, New Zealand, Sweden, Switzerland and United States have written summaries of the current technical progress in their several countries in various metal finishing techniques. While principal attention is given to electroplating other methods of coating surfaces are mentioned, including galvanizing and application of organic coatings.

The articles include in some instances illustrations of equipment and names of firms. In some cases extensive reference sections are included.

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Design for Efficiency

Economical design of consumer products to assure desirable products at reasonable cost will be discussed by F. J. VanPopple, general manager of General Electric Company's Air Conditioning Division, Bloomfield, N. J. at a conference on problems of improving industrial efficiency. The conference will be held at Urbana, Ill. It is sponsored by Engineering Economy Committee of the American Society for Engineering Education and arranged by Arthur Lesser, Jr., head of the Department of Economics of Engineering at Stevens Institute of Technology, Hoboken.

Manuscripts Approved and Soon to Be Published

Manuscripts approved for publication include:

Survey of Corrosion Control in California Pumping Wells by Frank E. Davie and Preston W. Hill.

Fingerprint Remover Compounds—Investigation of Synthetic Fingerprint Solutions by Stanley L. Eisler and Harry L. Faigen.

Gasket Surface Corrosion as Encountered in Austenitic Stainless Steel in a Chemical Plant by E. V. Kumkel.

Some Early Patents on Cathodic Protection (Second of a series of six articles) by Robert Pope.

Electrical Measurements in the Selection of Bolt Materials for Service Underground by W. J. Schwerdtfeger.

Corrosion Control in Gas Lift Wells by D. A. Shock and J. D. Sudbury.

The Tank Ship and Its Corrosion Problems by J. D. Sudbury, D. A. Shock and F. W. Mann.

Testing Coatings for Tank Car Linings by Robert J. Spraul.

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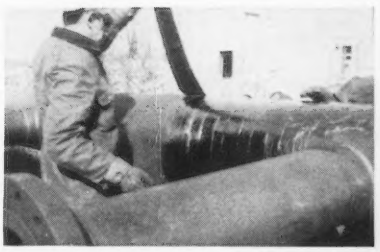

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Pittsburgh Diffraction Conference Set Nov. 3-5

A joint meeting of the American Crystallographic Association and the Twelfth Annual Pittsburgh Diffraction Conference will be held Nov. 3-5 at Mellon Institute, Pittsburgh. Sessions are being arranged on instrumentation and methods, metals, neutron diffraction, small-angle scattering and silicates and related structures. Papers on general diffraction subjects will be accepted also.

Contributed papers will be considered in the order received. Titles should be sent to Prof. G. A. Jeffrey, Program Chairman; University of Pittsburgh, Pittsburgh 13, Pa. before September 1. A copy of the preliminary program may be obtained on request from Dr. P. H. Koh, Allegheny Ludlum Research Laboratories, Alabama Ave., Brackenridge, Pa.

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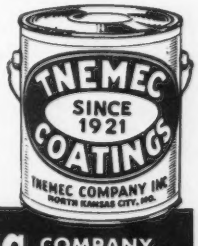

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Technical Committee News

Cathodic Protection Spatial Criteria Are Urged

Cooling Water Test Procedures Reviewed At Houston May 7

A tentative report on the result of some testing procedures was read to those attending the meeting of T-5C-1 on Cooling Waters "South Central Region" held at the Ben Milam Hotel in Houston May 7. W. G. Ashbaugh, Carbide & Carbon Chemical Co., Texas City, Texas, reporting for the Testing and Inspection Study Committee, said that the committee is trying to complete laboratory tests to determine best methods for testing inhibitors for use in Gulf Coast cooling waters.

There were 45 members and guests at the half day meeting. C. P. Dillon, Carbide and Carbon Chemical Co., Texas City, outgoing chairman of the committee, reported that J. L. Ragan, The Celanese Corporation of America, Bishop, Texas, the new chairman of T-5C-1, was unable to attend the meeting. Mr. Dillon presided in Mr. Ragan's absence. In an election held during the meeting, E. L. Haile, Monsanto Chemical Co., Texas City, was elected vice-chairman of the committee and R. H. Maurer, Celanese Corporation of America, Bishop, Texas, was elected secretary.

W. A. McMillan, Mathieson Chemical Company, Lake Charles, La., reported that his study committee on cooling waters for once-through systems had completed a questionnaire. One member of this study committee said that from replies on the questionnaire he felt that control of velocity in once-through cooling water systems is one of the most important factors.

A new study committee set up for the purpose of studying non-ferrous alloys and stainless steels in cooling water systems was formed during the meeting. F. Pledger, E. I. du Pont de Nemours & Company, Inc., Orange, Texas, was appointed to head the new study group.

Fink Is Vice-Chairman Of T-3 General Group

Frederick W. Fink, Battelle Memorial Institute, Columbus, Ohio, has been elected to the vice-chairmanship of NACE technical Group Committee T-3, General. F. M. Watkins, Sinclair Research Laboratories, Inc., Harvey, Illinois, chairman of T-3 says that Mr. Fink's experience and wide interest in many phases of corrosion combined with his ability well qualify him for the office of vice chairman.

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The Eleventh Annual Conference and Exhibition of NACE will be held in Chicago in March, 1955.

McPherson Is Elected To T-5A-5 Position

J. L. McPherson, with Blaw-Knox Company, Library, Pennsylvania, was recently elected to the office of vice-chairman of NACE committee T-5A-5. The election of Mr. McPherson was announced by James L. English, Oak Ridge National Laboratories, Oak Ridge, Tennessee, chairman of the committee. Mr. McPherson is to assume his responsibilities as vice-chairman immediately and will serve until March, 1955.

Task Group T-5A-5 on Nitric Acid has recently prepared a questionnaire to be used to make a survey of industrial problems in handling nitric acid. Other committee work currently under way includes six projects concerning materials of construction for use and equipment handling nitric acid. These six projects were assigned to Task Group T-5A-5 by Group committee T-5 on Corrosion Problems in the Process Industry.

Unit Prepares Report on Minimum Potential Criteria

"Some Observations of Cathodic Potential Criteria in Localized Pitting," a report from NACE Technical Unit Committee T-2C on Minimum Current Requirements for Cathodic Protection, authored by L. P. Sudrabin, Electro Rust-Proofing Corp., Belleville, N. J. has been approved for publication by the unit, group and technical practices committee chairmen. Publication within two months is expected. Mr. Sudrabin is chairman of unit committee T-2C.

Mr. Sudrabin says that in order to help understand the meaning of potential measurements, protective current was applied to a model cell including the basic spatial, electrical and environment factors found in localized pitting. Used in these experiments were corroding medias having a specific resistivity of 15-22,000 ohm-cm and 160 ohm-cm.

The report includes equipotential lines measured in the corroding media graphically shown for the coupled pitting system. The open circuit potentials of the anode and cathode elements including that of mill scale were observed.

Equipotential lines, also graphically shown in the report, indicate when protective current was applied and the corrosion current flow from the pit had ceased. It was noted that the equipotential line corresponding to the open circuit potential of the anode, is located at

(Continued on Page 16)

Study of Spatial Factors Recommended By Committee T-2C

A study directed towards establishing the spatial factors in cathodic protection criteria would be most productive according to a member of NACE Unit Committee T-2C on Minimum Current Requirements for Cathodic Protection. This statement was made following an indication that all the "null" efforts he had observed failed to include some or all of the IR drop form of cathodic polarization, which is particularly important in the protection of pipelines in high resistivity soils. The observation was made during the meeting held by T-2C in Kansas City during the recent NACE Annual Conference. Several other interesting observations concerning cathodic protection were voiced at the meeting. One member reported that some preliminary polarization studies conducted on specimens of mill scale in flowing sea water has revealed a potential of the mill scale to be +.235 volts measured against a saturated KCl calomel reference electrode. It was expected that a report on these studies will be available to committee T-2C at its next meeting.

L. P. Sudrabin, Electro Rust Proofing Corp., Newark, New Jersey, chairman of T-2C, reported on a study of cathodically protected steel in 73 percent caustic solution at 100 degrees Centigrade. He said the potential of the unprotected steel was found to be —1250 millivolts measured against a saturated KCl calomel half cell maintained at room temperature and a potential of —1300 millivolts was observed when 80 percent corrosion reduction was attained with cathodic protection.

In a discussion on the effect of temperature on corroding structures one member cited an example where temperature decrease resulted in increased corrosion of pipes buried in soil.

There was comment on the lack of field investigations by pipe line operators that add substantial information to the establishment of protective criteria. Much of the practical and fundamental studies are carried out in laboratories or on marine structures. While the information gained in the other fields of cathodic protection is helpful in understanding the principles and consolidating the general knowledge, experience indicates need for better interpretation of criteria such as measuring —.85 volts to a Cu-$CuSO_4$ over the pipe, 10 feet away or in a remote location. The committee feels a testing practice should be established which can be relied upon to indicate the amount of corrosion control required.

Unit Prepares—

(Continued From Page 15)

some distance from the cathode. To observe any relation between a break in the potential-log current relation and flow of corrosion currents in the pit the D C null potential measurement technique was used.

The observations made Mr. Sudrabin support the following:

a. The potential measurement of the cathodically protected structure should include all the IR drop form polarization resulting from the flow of the protective current thru the cathode resistive element. The latter resistive element includes the cathode surface resistance plus the resistance of the electrolytic cell adjoining the cathode surface.

1. The boundary of the cathode electrolytic resistive element, at which the reference electrode should be positioned, seems to be determined by the size and spatial positions of the anode and cathode of the corroding system. The smaller the anode the closer the reference electrode should be placed to the structure.
2. The location of the reference electrode becomes more important as the environmental resistivity increases.

b. The ratio of protective current required to corrosion current increases with increasing media resistivity.

c. Mill scale can be more cathodic than copper.

"Corrosion Products" Is New Name of T-3B

The name and scope of T-3B has been changed. The new name is "Corrosion Products" replacing the former "Identification of Corrosion Products." The scope now is "To procure, assemble and correlate information on the nature of corrosion products for a better understanding of mechanisms involved in their formation." The committee is currently working on a list of references relating to corrosion products of certain metals. Literature on corrosion products is being surveyed preparatory to dividing the field and assigning individual committee members responsibility for abstracting available information. A. H. Roebuck, Argonne National Laboratory, Chicago, Illinois, was recently elected to the chairmanship of the committee. C. E. Imhoff, Allis-Chalmers Mfg. Co., Milwaukee, Wisconsin is the retiring chairman.

A change in scope of another T-3 Unit committee has also been approved. The committee is Technical Unit Committee T-3C on Annual Losses Due to Corrosion. The new scope is "To identify costs which should properly be charged to corrosion on an individual industry basis and to collect data on the cost of corrosion to industry and to the national economy as a whole." The committee hopes that under the new scope more progress may be made in accumulating data on cost of corrosion. The new scope will enable the committee to reduce the problem to workable size and then to assign responsibility for portions of the problem. F. N. Alquist, The Dow Chemical Company, Midland, Michigan, is the Chairman of T-3C.

Tentative Procedure for Testing Sulfide Inhibitors Agreed On

A tentative procedure for testing inhibitors for use under hydrogen sulfide conditions in oil and gas wells was formulated at the May 24 meeting held by Unit Committee T-1K. Nine members of the committee attending the all day meeting held in Dallas, agreed to run tests on several inhibitors following the tentative testing procedure as drawn up by the committee. Results of these tests and the testing procedure are to be included in a paper which will be presented at the meeting of the NACE South Central Regional Division in Dallas, October 12-15, 1954.

The tentative testing procedure was based on results of tests run in several separate laboratories on similar inhibitors. The committee feels that the information derived from the results of these preliminary tests has enabled them to formulate the best procedure by which corrosion inhibitors may be tested for use under hydrogen sulfide conditions.

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Articles on corrosion control matters may be submitted for publication in Corrosion without invitation.

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Oilfield Structural Plastics Test Data Are Given

Studies Indicate Short Time Tests Correlate Poorly

In October of 1952, Technical Practices Committee No. 1 created a committee to study oil field structural plastics. The committee was formed for the purpose of investigating advantages and/or disadvantages of structural plastic materials for use in the oil producing industry. The committee was designated TP-1J.

Under the reorganized technical committee structure, TP-1J now has the status of a Unit Committee functioning under Group Committee T-1 on Corrosion in Oil and Gas Well Equipment. The membership of the Unit Committee, now designated T-1J, remain the same and its scope is unchanged. The committee is composed of NACE members from oil company consumers, manufacturers of basic raw materials and fabricators of finished products. By creating an association among the three groups, the committee hopes to expedite development of satisfactory structural plastic materials for the oil producing industry. The committee also hopes that through its activities, engineering data will be amassed such that materials now available can be used within their limitations, thus preventing premature failures of structural plastic materials caused by improper application. This committee recognized that such premature failures damage the reputation of plastic materials and serve to delay urgently needed development and test work.

At the organizational meeting of the committee, it was agreed to attempt to amass and correlate all presently available data concerning plastic structural materials. Reports of laboratory investigations performed by various oil company consumers were solicited and a questionnaire was prepared and distributed to members of operating companies in an effort to assimilate as much available field experience with plastic as possible.

After a year, the committee presented material to TP-1 at a meeting in Tulsa, Oklahoma on October 7, 1953 during the 1953 NACE South Central Regional meeting. The data presented and discussed by TP-1 represents some preliminary observations on the properties of structural plastic materials including some reports on laboratory investigations of plastic products, primarily tubular goods.

Although there have been many requests for reprints of the material presented by T-1J at the October 7 meeting the committee feels that much more conclusive work needs to be done before an official committee report can be made. This article is a report on the material presented by TP-1 at Tulsa and is not intended to represent official committee action.

Included in this article are four papers presented by T-1J members as a part of the committees progress report to TP-1. The emphasis of these papers is on testing techniques and methods to be employed in plastic testing.

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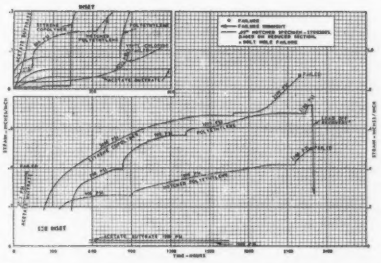

Figure 1—Creep tests on plastics at 80 degrees F.

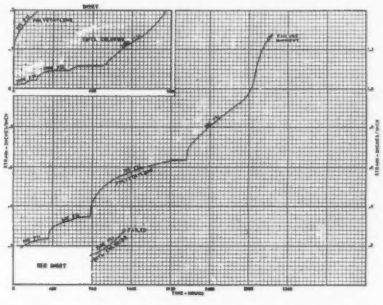

Figure 2—Creep tests on plastics at 110 degrees F.

Testing procedures for qualitative screening of plastic materials are outlined and procedures recommended for procurement of engineering data to be employed in design of plastic installations is included. Wide differences of opinions are evidenced concerning the testing methods and techniques which should be employed for evaluation of plastic products. It seems to be generally agreed that 1) the determination of short term tensile strength data has no correlation with long term properties of plastic; 2) properties of many plastics are drastically affected by the media by which they are tested; 3) change in temperature has a definite and significant effect on the properties of plastic, and 4) fatigue properties must be taken into account when designing plastic installations.

Creep Tests Are Good To Get Stress Data

By A. C. LEVINSON
Phillips Petroleum Co.

The ability to withstand stresses for long periods of time is essential in most engineering structures. Since short-time tensile data apparently have no correlation with the long-time properties of plastics, creep testing seems to be the only method by which reliable allowable stress data may be obtained. This method does not consider such elements as fatigue or collapse, and in some cases joining methods.

Short-time data are valid only for the length of time to make the test, although this information may be used for qualitative or comparative purposes within a single class. Tensile strengths and working stress data as presently listed by most manufacturers have no design value whatsoever. Working stress data appear to have been based on short-time data to which large safety factors have been applied. The basic engineering data used in the selection of these safety factors and in the selection of the recommended and listed maximum allowable working stresses are lacking. The latter point is well illustrated by the recommended stresses which vary considerably with the diameter of the pipe.

Creep-type tests have been using flexural stresses, but in plastics there is no true relationship between flexure and tensile strengths. Creep tests based on flexure strength can therefore lead only to qualitative results.

Efforts to obtain valid and useful long-time data are made difficult by the complications of environment and the possibilities of changes in the composition of a given type of plastic. Some media, even water, can alter the physical properties of plastics. Temperature variation has a definite effect on these materials and fatigue properties must be taken into account. Filler and plasticizer additions to resins as well as changes in the composition of the basic resins are effective in changing the physical properties of these materials. Acetate butyrate pipe, for example, made from reground stock is very notch sensitive, while pipe from new stock is comparatively free of this defect. Tremendous changes in the physical properties of polyethylene are made possible by large variations in molecular weights of this resin. Vinyl resins are extremely variable in composition and their properties vary considerably. All of the above simply serve to illustrate that the plastics present a very complex problem and to point out factors which must be considered in any large scale attempt to find engineering design data.

Some explanation will be helpful in understanding the creep curves (Figures 1 and 2). In each of the categories (acetate butyrate, polyethylene, etc.), an effort was made to test only the finest quality products available. Some products were discarded after short-time tests in which they showed no promise. All of the specimens were cut from lengths of pipe; hence, only the longitudinal creep values were obtained. Cross sections were rectangular and gage lengths of 2, 4 and 8 inches were used. Generally, a specimen was stressed at low levels at the start of a test. Free-hanging loads were used and when static conditions persisted the loads were increased. This "step" method is readily apparent on the curves.*

* The vinyl chloride creep curve inadvertently does not show an increase stress at 384 hours. From this point the stress was 5000 psi.

(Continued on Page 18)

Glass-Plastic Laminate Strength Is Investigated

(Continued From Page 17)

Tests at 80 F were made in a thermostatically-controlled room. Hot air, which was also controlled thermostatically, was used for the tests at 110 F. Humidity was not controlled. The slight variations from the normal curve were probably due to the minor temperature and humidity changes.

Two observations were made of unexpected phenomena during the course of creep testing. Any stress level which would not produce additional elongation for a period of several hundred hours would not cause failure.* Also, total elongation before failure was found to be highly dependent upon the loading sequence. The "step" procedure produced less total elongation than a single stressting at the highest level of the "step" process. To illustrate this, polyethylene stressed by the step method (see creep curve) showed a total elongation of 57 percent at 900 psi. Another specimen stressed from the beginning at 900 psi showed a total elongation of 92 percent.

The following table shows the short-time properties of the materials tested:

Material	Tensile Strength	Elongation, 2", %
Polyethylene	1200	286.0
Acetate Butyrate	5100	60.0
Styrene Copolymer ...	4300	50.0
Vinyl Chloride	7000	25.0

In analyzing these data, it may be reasoned that in some applications the elongation may be the limiting factor. That is, the applied stress may have to be lower than the maximum permissible.

Earlier in this discussion, mention was made of the composition effect on the properties of plastics. It is because of the great changes in properties associated with the changes in composition that the reader is cautioned against a broad use of the creep curves (Figures 1 and 2).

Laboratory Testing of Glass-Plastic Laminates

By R. S. TRESEDER
Shell Development Co.

The development of improved glass-plastic laminated materials for oil field applications would be accelerated if laboratory evaluation tests were designed to test materials under conditions closely related to those encountered in service. Mechanical strength tests commonly used provide valuable information, but fail to evaluate a property of these materials which is of considerable importance in oil field applications. This property is the decrease in ability to support a sustained load when exposed to water and when subjected to a warm temperature. For example, a glass-plastic laminate (polyester type) with an ultimate strength of 44,000 psi as determined by rapid flexure test in air at 75 degrees F failed in less than one minute when subjected to a stress equal to 50 percent of the ultimate strength while immersed in water at 150 degrees F. This test is not the same as the common water-resistance test for such materials wherein a sample is soaked in water at an elevated temperature for a few hours and then subjected to a rapid ultimate strength test. With such a test only moderate, e.g., 10 percent, losses in strength are observed with most materials.

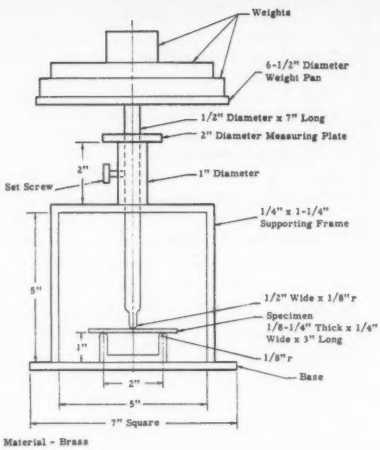

Figure 3—Apparatus for constant load flexure tests.

A comprehensive laboratory test program for glass-plastic laminates therefore should include long-term tests with samples of pipe or tubing exposed under simulated oil field conditions, e.g., water at elevated temperatures, under the various types of loading that might be encountered, such as tension, burst, collapse, shear, fatigue and impact. Creep rates as well as time to failure would be measured. Failure could take the form of either weeping of fluids or rupture of the pipe. Admittedly such testing is laborious, but it is the only sound way of providing the field engineer with data needed for intelligent selection of materials for specific applications. Some of the laboratory test procedures that are being used to obtain data of this type will be discussed briefly at the end of this report, following discussion of the screening test method.

Constant Load Flexure Test

The manufacturer of glass-plastic laminates has a need for a simple screening test method for evaluating the various products that he can fabricate from the variety of resins, glass fibers, glass fiber finishes, curing agents and curing conditions that are available. Since the existing test procedures for plastic materials fail to demonstrate one of the major potential weaknesses of these materials for oil field applications, i.e., their weakness under sustained load in water or at elevated temperatures, a simple test method has been devised which provides useful information regarding this property of glass-plastic laminates. This test, which is called a Constant Load Flexure Test is, described in detail below. The flexure test was adopted because creep rates could be measured more conveniently on flat specimens under constant flexural loading than either compressive or tensile loading. Comparative tests showed that similar results were obtained by all three types of loading. It should be emphasized that this tests is designed as a screening test and is intended to provide data showing the relative resistance of various materials to loss of strength due to water or to increased temperature, but it is not intended to provide engineering data from which specific performance could be predicted.

Test Method

Apparatus

Loading Fixture. As shown in Figure 3.

Constant Temperature Water Bath. Of such size that above fixture can be placed inside bath and specimen will be totally immersed when water is added. Temperature control, ±2 degrees F. Use tap water in bath.

Constant Temperature Oven. Any convenient size into which above fixture will fit. Temperature control, ±5 degrees F.

Specimens. 0.25-inch wide by 3.0-inch long strips cut from ⅛-inch to ¼-inch thick panels using abrasive wheel. Specimens wiped and allowed to air dry thoroughly before use.

Procedure

Place loading fixture in oven (air test) or water bath (water test) and adjust temperature to value desired. Center the specimen on supports provided and, after conditioning (5 minutes for water test, 1 hour for air test), apply load to midpoint of specimen by adding weights to platform. Load specimen to give desired maximum fiber stress, using formula

$$L = \frac{2Sbd^2}{3l}$$

where L = Load, lb.
S = Maximum fiber stress, psi
b = Specimen width, in.
d = Specimen thickness, in.
l = Distance between supports, in.

(Continued on Page 20)

TABLE 1

Sample	Resin Type	Flexural Strength in Air at 75° F, psi.	Stress Applied in Test psi.	TIME TO FAILURE, HOURS		
				75° F	150° F	
				Air	Air	Water
A	Polyester.....	51,300	25,700	>213[a]	>215[a]	1.9
B	Polyester.....	46,400	23,200	>240[a]	74	0.2
C	Epoxy.....	81,500	40,800	.....	.....	1.3
			25,700	.....	.....	22.9
D	Epoxy.....	79,100	39,500	.....	.....	50
			25,700	.....	.....	>576[a]

[a] Creep rate practically zero at indicated termination time.

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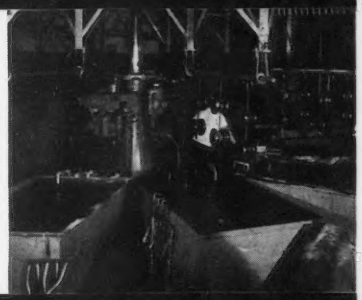

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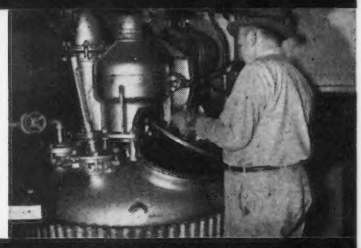

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Glass-Plastic–

(Continued From Page 18)

Measure deflection of specimen within one minute after applying load and at suitable intervals thereafter. Measure deflection by measuring distance between bottom of loading pan and top of the fixed plate using transfer calipers and vernier calipers. In short-term tests, determine the time when specimen failure occurs by placing a microswitch so that the descending load pan opens an electric clock circuit.

Evaluation of Results

Various materials can be evaluated for ability to withstand constant loads under a specific set of test conditions either by comparison of time to failure under severe test conditions or by comparison of time-deflection curves plotted on semi-log paper. Since this method is intended for obtaining comparative data, tests are best made under severe conditions in which time to failure can be obtained in a reasonable period.

Table 1 gives typical data obtained by this method with glass-plastic laminates.

In addition to showing the type of result obtained in this test, these data show that variations in strength under load in water at elevated temperature are much greater than variations in strength in air at ordinary temperatures as determined by rapid test. Water was found to have a much greater effect on the laminates than did crude oil. Produced brines were equivalent in effect to the fresh water used as a standard in these tests.

Deflection time curves for Sample D in the above table are presented in Figure 4 for three load values. These curves indicate that some materials will show a certain amount of creep initially, but after several hundred hours, the creep rate becomes essentially zero.

Constant Load Ring Crush Test

In a variation of the above test a ring specimen cut from tubing is used; this requires only minor modification of the test equipment (see Figure 5). Results from this test lack the comparative value of the flexure test owing to the difficulty of comparing data obtained with different size tubing. It is convenient, however, from the standpoint of providing an easy test of the effect of temperature and environment on the mechanical properties of tube samples. The procedure employed is essentially the same as that described above. A few typical results obtained with samples of commercial tubing are given in Figure 6.

Hydraulic Burst Test

As mentioned earlier, the testing of pipe or tubing as commercially fabricated is best done under conditions where the loading and manner of exposure closely simulate field conditions. In the case of line pipe and well tubing, it is desirable to know the maximum internal pressure that can be sustained for an indefinite time without failure. Apparatus for determining the time to failure of 15 inch long tube or pipe specimens under constant internal hydraulic pressure at controlled temperature is shown schematically in Figure 7.

It should be noted that in this design the end thrust load upon the tube closure is carried by the axial rod, thus reducing the axial tension on the tube. Test results obtained with this apparatus may not be directly comparable to those obtained with closures designed so that the axial tension is carried by the tube. Many complex combinations of stresses may be encountered in practice; the test described here is merely one considered significant in many applications and possessing advantages of simplicity.

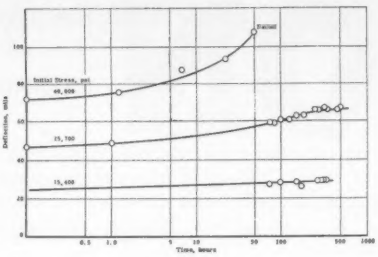

Figure 4—Flexural deflection-time curves of laminate D in water at 150 degrees F.

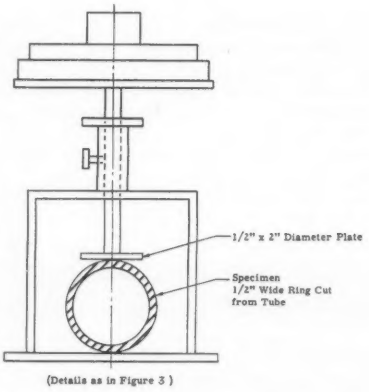

Figure 5—Apparatus for constant load ring crush tests.

Typical results for a sample of 3½-inch OD by ¼-inch thick polyester type tube are given below:

Test Presure, psi	Time to Failure 110° F	150° F
600	9 hrs.	1 hr.
400	16 days (leaks)	—
300	2 mos. (weeping)	8 hrs.
200	—	6 days

In rapid ultimate tests, the hydraulic burst strength of the above pipe was 1000 psi at 75 degrees F and 1500 psi at 150 degrees F. The manufacturer's value for burst strength was 1200 psi, and the recommended maximum working pressure (burst) was 300 psi (to 150 degrees F).

Hydraulic Collapse Test

Tests similar to the above can be made in which a constant external hydraulic load is applied. This is of interest in connection with oil well tubing and casing applications. Apparatus for this test is shown schematically in Figure 8. Using this apparatus the following results were otbained with the same tubing:

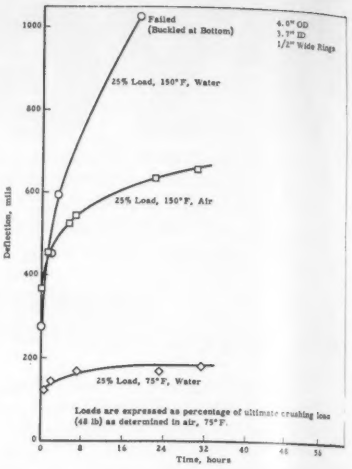

Figure 6—Constant load ring crush tests of glass cloth reinforced polyester pipe.

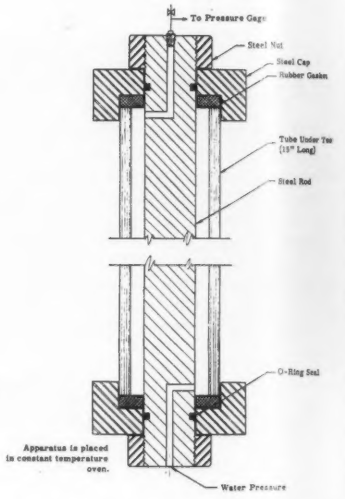

Figure 7—Apparatus for hydraulic burst tests.

Test Pressure, psi	Time to Failure 110° F	150° F
500	9 hrs.	—
400	—	0.5 hr.
200	27 days	12 hrs.
100	—	100 hrs.

In rapid tests the hydraulic collapse strength of this tubing was 1500 psi at 75 degrees F and 800 psi at 150 degrees F. The manufacturer quoted a value of 1500 psi, and recommended a maximum working pressure of 500 psi (to 150 degrees F).

Summary

Laboratory tests of several types have demonstrated the significant loss of strength that occurs with glass-plastic laminated materials when exposed under load to water or to elevated temperatures. A simple flexure test has been developed for obtaining relative data for resistance of such materials to this type

(Continued on Page 22)

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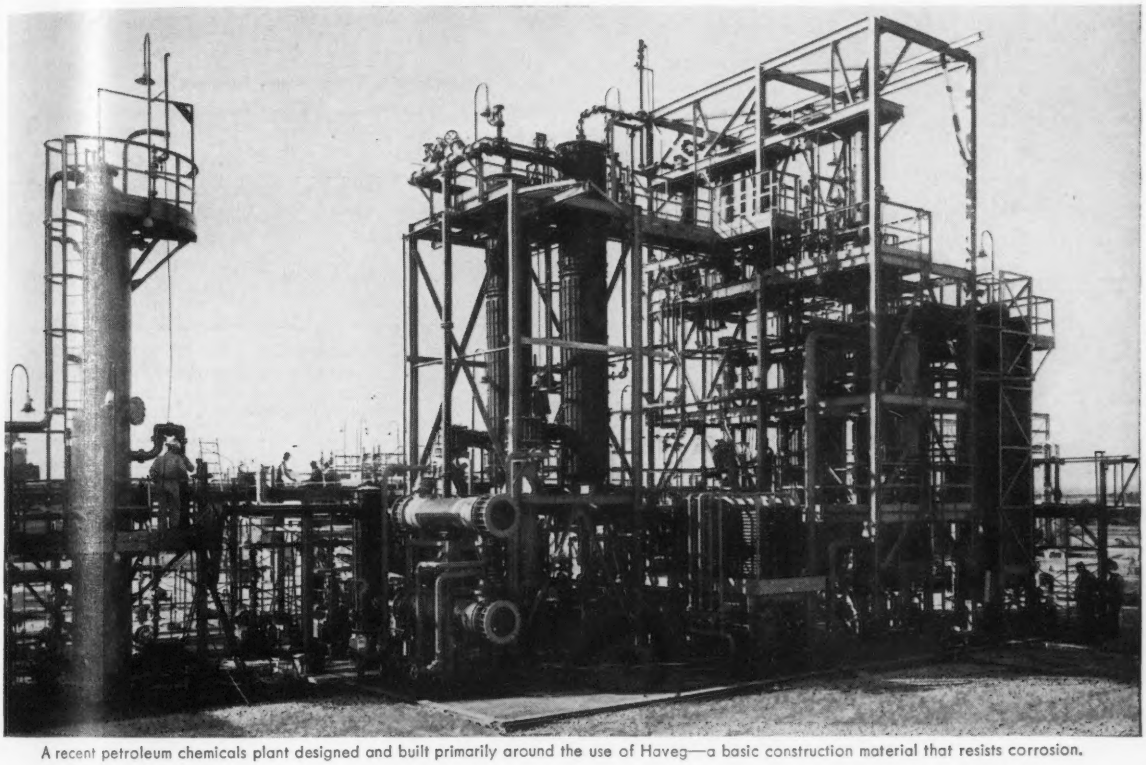

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Glass-Plastic–

(Continued From Page 20)

of failure. This method should be useful as a screening test to guide selection of the best materials for commercial production. Test procedures for evaluating actual pipe samples under simulated field conditions are described.

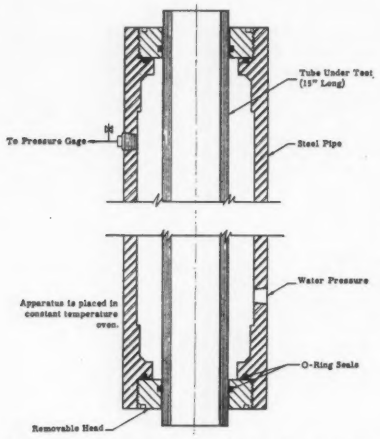

Figure 8—Apparatus for hydraulic collapse tests.

Tensile and Bursting Strength Tests Made

Laboratory tests have been run on small specimens as well as full size pipe samples. The bursting and tensile strengths were determined at various temperatures and after the samples had been exposed to water and oil.

Table 2 shows the tensile strength as determined on full size pipe specimens at room temperatures. The results show reasonably good comparison between manufacturer's claims and the actual tensile strength determined.

Table 3 gives the test results obtained on full size pipe specimens of joint tensile strength. As noted, only one glued and one threaded joint of the glass reinforced pipe were tested. Of these, the threaded joint gave the best results, being 100 percent of the pipe strength. In extruded pipe the only general conclusion that can be made is that in two out of three joints tested a serious loss in strength was noted.

Table 4 gives the results of bursting pressure tests run on full size specimens at room temperature. As shown, this property varied from 64 to 110 percent of the manufacturer's claims on the glass reinforced material. The extruded pipe was consistently above strength claimed by the manufacturer.

Table 5 shows the tensile strength of small specimens as affected by a water or oil soak. The specimens were allowed to reach equilibrium in the test solution then pulled on a standard tensile machine. The tensile strength of the glass reinforced materials varied from 41 to 106 percent of original after an exposure to water. In oil, the tensile strength varied from 46 to 115 percent of original. The extruded thermoplastic appeared more uniform in these tests than the reinforced, having variations

(Continued on Page 24)

TABLE 2—Tensile Tests, Room Temperature

Thermosetting Pipe	Breaking Load	Tensile Stress	Percent of Mfgr's. Claims
A 3¼ O.D. x 2⅞ I.D.	29,000	11,400	114
B 3½ O.D. x 3¼ I.D.	11,170	8,450	84
C 4 O.D. x 3⅝ I.D.	24,400	12,980	81
D 2⅜ O.D. x 2 I.D.	22,200	17,250	....
Extruded Pipe			
E 3¼ O.D. x 3 I.D.	6,060	4,920	123
F 2⅜ O.D. x 2 1/16 I.D.	7,110	6,540	131

TABLE 3—Joint Tensile Tests, Room Temperature

Thermosetting Pipe	Breaking Load	Percent of Tested Pipe Strength
A. 3¼ O.D. x 2⅞ I.D. threaded upset ends	22,370 lb. in pipe	100%
B. No. Test	.....	.....
C. 4 O.D. x 3⅝ I.D.	18,870 lb. in coupling	77%
D. Couplings not available	.....	.....
Extruded Pipe		
E. 3¼ O.D. x 3 I.D. glued coupling	5,560 lb. in pipe	100%
F. 2⅜ O.D. x 2 1/16 I.D. glued coupling	4,780 lb. in coupling	67%
F. 2⅜ x 2 1/16 I.D. cut threads	4,170 lb. in threads	59%

TABLE 4—Bursting Pressure, Temperature 65° F.

Glass Reinforced Thermosetting Pipe	Bursting Pressure, Psi.	Stress, Psi.	Percent of Mfgr.'s Claim
A	1,120 Avge. 1,100 min.	6,439 6,325	64% 63%
B	835 Avge. 755 min.	11,273 10,193	110% 100%
C	830 avge. 820 min.	12,863 12,710	80% 79%
D	3,175 max. 1,700 min.	18,521 9,914	No claim No claim
Extruded Pipe			
E	380 avge. 360 min.	4,725 4,500	117% 112%
F	930 avge. 880 min.	6,700 6,346	134% 127%

TABLE 5—Plastic Pipe Tests
Tensile Strength Tests of Small Specimens

Glass Reinforced Thermosetting Resins	As Received	TENSILE STRENGTH, Psi. After Water* Exposure	After Kerosene* Exposure
A 3½" O.D. Tubing, new type	10,000	10,600 (106%)	7,635 (76%)
B 3½" O.D. Line Pipe, new type	7,500	3,100 (41%)	8,675 (115%)
4½" O.D. Line Pipe	7,200	6,800 (94%)	7,900 (110%)
3½" O.D. Line Pipe	11,100	6,170 (55%)	5,570 (50%)
D 2⅜" O.D. Tubing	7,675	4,080 (53%)	3,542 (46%)
C 4" O.D. Line Pipe	16,750	11,975 (71%)	15,000 (90%)
T Tank Material	15,800	11,050 (70%)	13,550 (86%)
Extruded Thermoplastic Resins			
E Line Pipe 3" I.D.	4,860	4,950 (106%)	3,450 (71%)
F Line Pipe 2⅜" O.D.	7,340	7,200 (98%)	7,470 (102%)

* Until weight change was zero.

Percent of fgr's. Claims
114
84
81
....
123
131

Percent of Tested Pipe Strength
100%
77%
....
100%
67%
59%

ercent of gr.'s Claim
64%
63%
110%
100%
80%
79%
No claim
No claim
117%
112%
134%
127%

NGTH, Psi. After Kerosene* Exposure
7,635 (76%)
8,675 (115%)
7,900 (110%)
5,570 (50%)
3,542 (46%)
15,000 (90%)
13,550 (86%)
3,450 (71%)
7,470 (102%)

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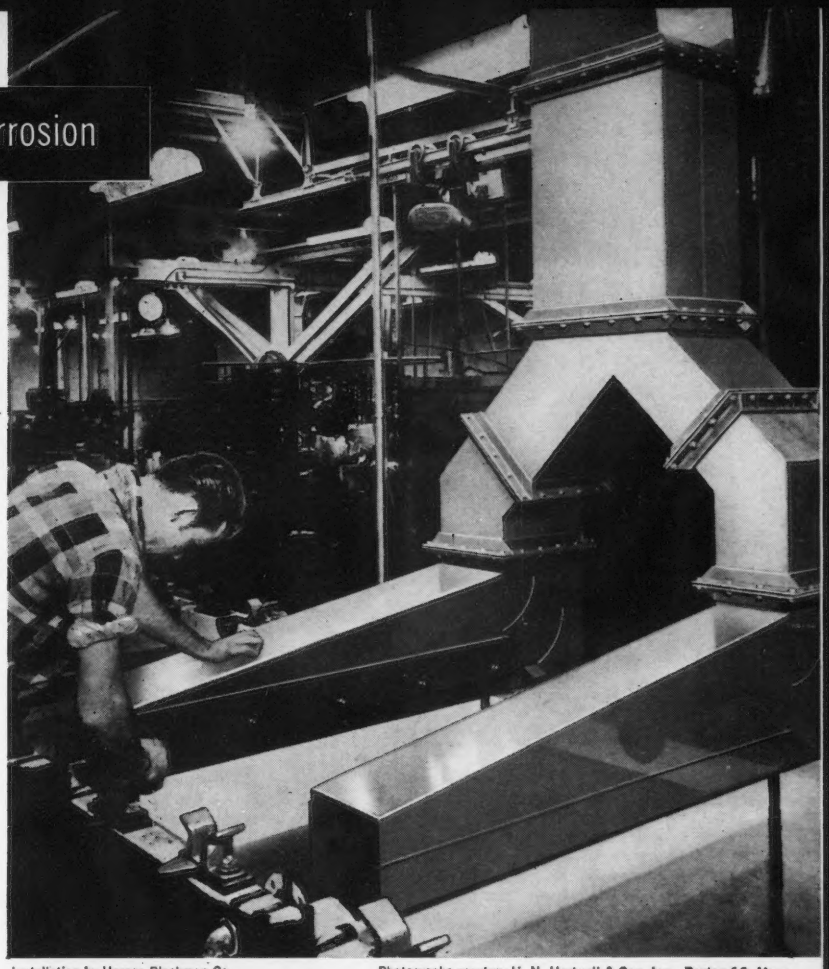
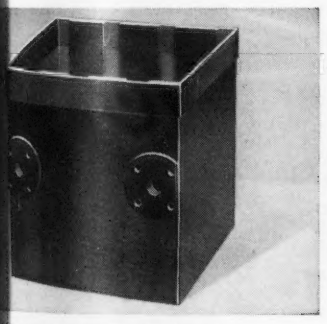


Installation by Horace Blackman Co.

Photographs courtesy H. N. Hartwell & Son, Inc., Boston 16, Mass.



★Eastman Kodak Co., Rochester, reports that Boltaron 6200 remained completely uncorroded by ferricyanide after 3 years, when no other material lasted 3 months.

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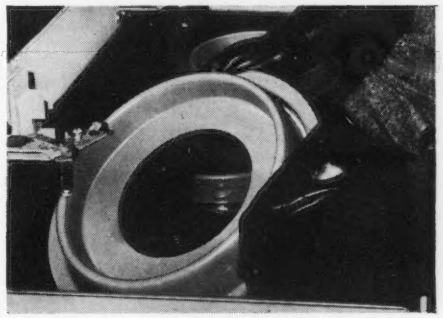

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Tensile and Bursting–

(Continued From Page 22)

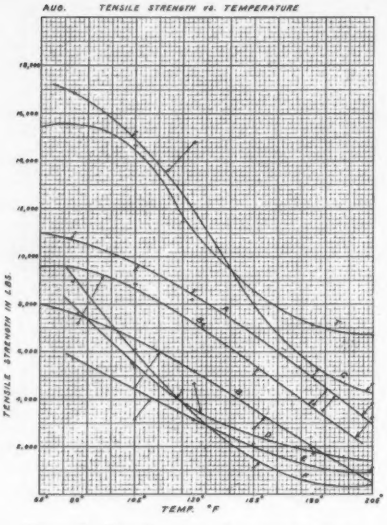

Figure 9—Tensile strength vs temperature.

from 98 to 106 percent in water with 71 to 102 percent variation in oil.

Figure 9 shows the variation of tensile strength with temperature. These curves represent the average of many tests on small sections. As noted, there is no straight line function which would allow extrapolation to determine strength under any conditions.

Tests have been run to determine the resistance of the material to ultraviolet light exposure, but no results are available yet.

Laboratory tests on these materials have been disappointing in that the manufacturer's claims cannot always be proved. Further, it appears that certain types of these materials do not possess the required chemical inertness.

In general, it is felt that these tests are indicative of only the relative merits of the various materials tested. It is not believed that these data give sufficient information to allow making definite design calculations for a given material.

Test results on full size pipe samples are given.

Temperatures, Combined Loads Data Compiled

By W. M. THORNTON
Atlantic Refining Co.

During the latter part of 1952, a series of tests was performed in an attempt to determine the suitability of one brand of reinforced plastic tubing for use as an induction string in salt water disposal wells. The product tested was manufactured by centrifugal casting. Reinforcing consisted of glass fibers and included layers of oriented fibers as well as random fiber mats. Polyester resins were employed as the thermosetting plastic.

Since the date of these tests, the manufacturer has incorporated several modifications in his product. The samples tested cannot therefore be considered representative of the product available today. It is believed, however, that the data obtained may prove of interest both to manufacturers and consumers of plastic tubular products. Considerable information was obtained relative to the manner in which such products fail. In addition, the data obtained serve to indicate some of the properties peculiar to reinforced plastics which must be considered in devising a rigorous evaluation program.

Devising a suitable test program for a material such as this presented several problems. Sufficient technical data are available on most metallic construction materials to allow testing of small specimens for such values as yield point, ultimate tensile strength and compressive strength from which the performance of a fabricated product may be calculated. Unfortunately, such data are not yet available for the majority of plastics. In addition, the product chosen for test is a reinforced material—deriving compressive strength from plastic and tensile strength from glass fiber reinforcing. As such, its strength is not uniform in all directions. To further complicate matters, discussions with the manufacturer disclosed that the bond between the glass fibers and plastic might be a weak point in the finished product. Thus it was feared that in small specimens the very short lengths of reinforcing fibers would not be effective. In view of these considerations, it was decided that tests must be conducted on relatively long lengths of fabricated tubing and that tests should consist, as far as possible, of subjecting those tubing lengths to the same types of stress which would be encountered in salt water disposal service.

Fortunately, equipment was available which could be adapted to such testing. This equipment, designed for testing oil well packers, is shown schematically, as modified for testing of plastic tubing, in Figure 10. This equipment consists essentially of a length of 5½-inch casing as a test chamber, a hydraulic ram or power cylinder, capable of imposing axial tensions or compression loads on the test specimen, a heating jacket and a high pressure manifold system for imposing stress conditions on the test specimen. The unit is capable of delivering 100,000 lb. axial compression or tension loads to the specimen, internal or external pressures up to 9000 psi and temperatures up to 400 degrees F. Water (fresh) was used as the working fluid.

TABLE 6—Test Data

	Temp. °F	Average Load	Range
Ultimate Collapse	90	1099	1000–1250
	140	530	500–540
Ultimate Burst	90	823	700–1000
	140	756	520–880
Ultimate Tensile	90	19,620	16,100–23,000
	140	13,680	8,500–16,100
Ultimate Compression	90	21,200	21,100–21,300
	140	12,320	11,000–14,100

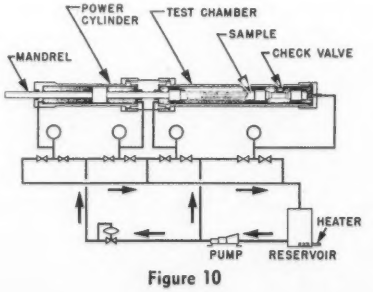

Figure 10

The standard joint of this type plastic tubing has a molded male thread on one end and a female threaded coupling cemented to the other end. The specimens tested were 10-foot lengths of 3½-inch tubing with a female coupling cemented to each end. Metal male-thread adaptors were fabricated to connect the mandrel and check-valve assembly to the plastic specimen. The thread lubricant recommended by the tubing manufacturer was used in these tests. In order that the strength of the molded plastic male thread might be determined, several tests of each type were conducted on specimens consisting of two 5-foot lengths coupled in the center in the same manner which would be employed in actual field use.

By following the flow through the system the manner in which the tests were conducted may be understood. If it was desired to subject a test specimen to an ultimate collapse test, fluid was pumped into the test specimen through the inlet at the far right end of the test chamber. This fluid was carried the entire length of the test specimen through ¼-inch tubing, then circulated in the annular space between the ¼-inch tubing and test specimen out through the check valve. From this point the fluid flowed through the annular space between the test specimen and the test chamber and out at the left end of the test chamber. This circulation was maintained until the temperature of the water at the inlet was equal to that at the outlet and had reached the desired test temperature. If then the flow was reversed, applying pressure at the left end of the test chamber and venting the right end of the test chamber to atmosphere, the check valve would hold, allowing pressure to be built up in the annular space between the test chamber and the test specimen; thus applying a collapse load to the plastic tubing under test. It may be seen that if the check valve were reversed and the fluid were first circulated into the left end of the test chamber, through the check valve to the inside of the test specimen and out the ¼-inch tubing into the manifold system, a reversal of circulation then would apply an internal pressure to the test specimen. In addition, at the same time pressure might be introduced either above or below the power piston creating axial tension and compression loads on the tubing under test.

The first series of tests run was to investigate the effect of temperature upon ultimate values of internal pressure, external pressure, axial tension and compression.

A summary of those data obtained is presented in Table 6. It may be noted that while some variation in strength existed among the various joints tested, the range was not as great as might have been expected from a reinforced material such as this. The effect of temperature is of interest. It may be noted that the average ultimate collapse at 140 degrees is approximately half the value obtained at 90 degrees. The ultimate compression at 140 degrees is only slightly more than half that obtained at 90 degrees. The ultimate burst at 140

(Continued on Page 26)

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Temperatures, Combined–

(Continued From Page 24)

degrees was very nearly the same as that at 90 degrees, while the ultimate tensile at 140 degrees was appreciably more than half that obtained at 90 degrees. Thus it becomes apparent that the plastic, which supplies the compressive strength in this reinforced material, is seriously weakened at elevated temperatures. The glass reinforcing which supplies the tensile strength is not so severely affected by increases in temperature.

This phenomenon becomes more apparent upon examination of graphs such as those shown in Figure 11. It may be seen from examining a graph of ultimate burst pressure versus temperature that appreciable strength reduction does not occur below a temperature of 130 degrees. The plot of axial tension load versus temperature discloses a similar temperature effect.

A different type curve was obtained in those tests in which the pipe was subjected to compressive loads. The graphs of collapse pressure and axial compression loads versus temperature indicate that compressive strength varies directly with temperature between approximately 70 and 180 degrees.

As previously mentioned, several specimens consisting of two 5-foot lengths of tubing coupled at the center by the standard threaded plastic coupling were included in each type of test. The values obtained are shown on the curves in Figure 11 by the circled points. It may be seen that no premature failures of the plastic threaded couplings occurred during the compression test. It will be observed that at 60 degrees, a low value was obtained in a collapse pressure test on a coupled joint. This failure, however, did not occur at the coupling but in the body of one of the 5-foot sections. The ultimate tension tests on specimens with a coupling in the center were in general slightly lower than the values obtained from testing 10-foot lengths. The lowest point, however, at 71 degrees, was a body break. The other three failures were thread failures at the center coupling.

The center coupling had no appreciable effect on the ultimate values of burst strength. One point obtained in test at approximately 168 degrees appears inordinately high. This is, as yet, unexplained.

From these tests, it was concluded that the strength of the standard plastic coupling was approximately equal to that of the body of the tubing itself with the possible exception of axial tension strength where a slight decrease was noted.

The next series of tests contemplated was an investigation into the effect of combined loads. In other words, would ultimate burst or collapse strength values be appreciably changed if the joint tested were, at the same time, under axial tension or compression loads. Accordingly, it was planned that specimens of pipe would be stressed to 50 percent of the ultimate axial tension value and then stressed to failure by application of external pressure. A certain amount of delay, however, existed between application of the axial tension load and application of the external pressure load. During this relatively short delay, the specimen failed from the tension load.

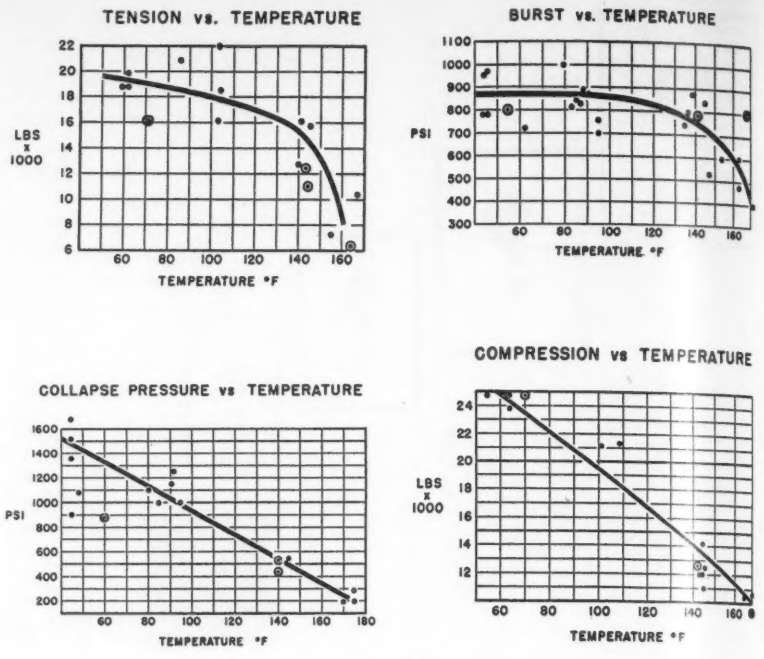

Figure 11

Subsequent attempts to accomplish the same type test also resulted in premature failure.

From these occurrences it became apparent that this material could not withstand the ultimate strength values obtained for more than a few seconds. As a result, a series of tests which we called "time failure" tests was initiated. In these tests, a test joint was subjected to a certain percentage of its previously determined ultimate burst collapse, tensile or compressive strength. This load was maintained until failure occurred or until four hours had elapsed. The time to failure was recorded.

Table 7 shows the results of time failure tests. The data obtained in time-failure tests of internal pressure show that at 500 psi internal pressure, failure occurred in 35 minutes. At 400 psi, failure occurred in one test after 57 minutes and in another at 400 psi, no failure occurred in four hours. At 300 psi, no failure occurred in four hours.

Similar data obtained in time failure tests of external pressure show that at 600 psi failure occurred in 45 minutes in one test and in another at 600 psi failure did not occur in four hours. No failure occurred within four hours at 500 or 400 psi.

The data obtained under axial tension time failure testing may be summarized as follows: Loads of 6000 pounds and below caused no failure in four hours. A load of 7000 pounds caused a failure in 45 minutes. At 7500 pounds, failure occurred in 140 minutes.

The time failure data obtained in axial compression testing are as follows: At loads of 10,000 pounds and below, no failure occurred in four hours. At 12,000 pounds failure occurred in one test after 15 minutes and in a second test after 17 minutes.

The actual mechanism through which failures under constant load occur is not

(Continued on Page 27)

TABLE 7

Time—Failure Data (Tension)

Temp. °F.	Load, Lbs.	Time to Failure (Minutes)
90	6000	No Failure
90	6000	No Failure
90	7000	45
90	7500	140

Time—Failure Data (External Pressure)

Temp. °F.	Pressure, Psi.	Time to Failure (Minutes)
90	400	No Failure
90	500	No Failure
90	500	No Failure
90	600	No Failure
90	600	45

Time—Failure Data (Compression)

Temp. °F.	Load Lbs.	Time to Failure (Minutes)
90	10,000	No Failure
90	10,000	No Failure
90	12,000	15
90	12,000	17

Time—Failure Data (Internal Pressure)

Temp. °F.	Pressure, Psi.	Time to Failure (Minutes)
90	300	No Failure
90	400	No Failure
90	400	57
90	500	35

TABLE 8

Results of Time Failure Data with Recommended Working Loads at 90° F.

	Ultimate in 4 Hour Test	Working Load W/1.5 Safety Factor
Internal Pressure, psi	300	200
External Pressure, psi	500	330
Tensile Load, lbs.	6000	4000
Compression Load, lbs.	10,000	6700

Tanker Corrosion Study Group Being Formed

Formation of a technical committee to study tanker corrosion has been approved. W. S. Quimby, The Texas Company, New York, N. Y., has accepted the responsibility of temporary chairman of the committee to see it through its formation stage. A permanent chairman will be elected following an organizational meeting. The committee will be formed as a Unit Committee under Group Committee T-3, General, and is to have the designation T-3H, Tanker Corrosion.

F. M. Watkins, Sinclair Research Laboratories, Inc., Harvey, Illinois, chairman of Group Committee T-3 says that estimates in literature admit corrosion costs of $60,000 to $125,000 per year for a T-2 type tanker. He feels that an active committee can be extremely helpful in reducing this heavy loss.

Corrosion Engineering Magazine in Japan

"Corrosion Engineering," a periodical published by the Japan Society for the Promotion of Science, Committee for Preventing Corrosion is now in its third year. A copy of the February, 1954 issue received at Central Office NACE includes short versions of articles published in Corrosion and articles on cathodic protection by Japanese scientists. The book also includes an abstract section in which the items are classified according to the NACE Abstract Filing System as well as a reproduction of the Technical Section contents of the 1953 issues of Corrosion.

Temperatures, Combined—

(Continued From Page 26)

fully understood. The occurrence of failures of this type, however, does illustrate the fact that conventional testing such as employed for testing of steel or other metallic construction materials is not applicable to plastics. All tests which have been reported in this discussion were conducted with the specimens immersed in water. It has been reported by others that the values obtained from tests conducted under immersed conditions are much lower than those which would be obtained if such tests were conducted in air. This again serves to illustrate some of the peculiarities of plastic products which require the development of entirely new concepts to be employed in their testing use.

A summary of the results obtained from time failure testing is presented in Table 8. The maximum load which the specimens could withstand for four hours is listed. While it is realized that four hours is a very short length of time when compared to life expected of in-hole tubing, it is believed that some weight might be placed upon these tests, in light of the times which elapsed before failures occurred at higher pressures. Previous figures, presented in this discussion list only one failure which occurred after an exposure of more than one hour. The other failures occurred in less than one hour. In a total of 36 time failure tests, 19 failures occurred. Fourteen of these failures occurred in less than one hour. In other words, if failure is to occur under conditions of this test it is quite probable that such failure will occur within one hour after the load is applied. Accordingly, the values obtained in time failure tests were considered to be, for practical purposes, the ultimate loads of this particular type of plastic.

The validity of these data have not been confirmed by field experience. It is hoped that sufficient field data will be amassed through the efforts of NACE Subcommittee T-1J to establish or disprove the accuracy of these findings. The very limited amount of information currently available suggests that the 4-hour test period is not of sufficient duration. It is known that one string of reinforced plastic tubing such as that tested failed in service after approximately one year under an axial tension load of approximately 4000 pounds. In at least this one instance, failure occurred even though a safety factor of 1.5 on the basis of these test data was employed.

The testing which has been described here represents a large expenditure of time and money upon the part of one oil company. The data are not nearly complete, in fact, they serve principally to indicate the tremendous volume of work yet to be done. It is hoped that through the combined efforts of consumers, manufacturers of raw materials and product fabricators, sufficient technical information on plastics may be amassed to allow their intelligent beneficial application within the oil producing industry.

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TP-19 Corrosive Effects of Deicing Salts—A Progress Report by Technical Practices Committee 19. *Corrosion*, January, 1954, issue. NACE members $.50; Non-members $1 per copy.

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1951—January, February, March, October.

1952—March, April.

1954—January.

Indices to Corrosion technical literature have been published as follows:

5-Year Index, 1945-49 inclusive and
Index to Vol. 6, 1950 ..... December, 1950
Index to Vol. 7 ..... December, 1951
Index to Vol. 8 ..... December, 1952
Index to Vol. 9 ..... December, 1953

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General News

Armour Lists Progress On Corrosion Projects

Industrial Research Newsletter, published monthly by Armour Research foundation of Illinois Institute of Technology, Technology Center, Chicago announces several developments of importance in corrosion science.

New stainless steel alloys with improved high-temperature strength have been developed by Cornell Aeronautical Laboratory, Inc., Buffalo, N. Y. These alloys are basically chromium-nickel stainless steels, modified with small additions of titanium and boron.

Baldwin-Lima-Hamilton, Baldwin, Pa., is planning a laboratory equipped with a 100-ton press, sintering furnace for investigating powder metallurgy problems.

Organic peroxides are being produced from gum turpentine by the laboratories of the Naval Stores Station, U. S. Dept. of Agriculture, Olustee, Fla. Peroxides are used to catalyze polymerization of rubber and plastics.

Bituminous Coal Research, Inc., 2609 First National Bank Bldg. Pittsburgh, is conducting research to develop new spray-type stack-dust collectors to minimize corrosion and other forms of stack deterioration caused by water sprays, to reduce stack emission during soot blowing, and will publish data to help boiler plants operate within city stack-emission requirements.

Vol. I, Bibliography of Ozone Technology—first of series of ozone reference books being published by Armour Research Foundation is titled "Analytical Procedures and Patent Index" and deals with gaseous and liquid ozone analytical techniques. The book includes an index on ozone patents. Price is $5.25, payment must accompany orders for fewer than five copies. Order from Joseph Kowal, Armour Research Foundation.

Heating, Piping, Air Conditioning Contractors Addressed by E. A. Tice

E. A. Tice of Corrosion Engineering Section of The International Nickel Co., New York represented the National Association of Corrosion Engineers at the May 27 Atlantic City meeting of Heating, Piping and Air Conditioning Contractors National Association. Mr. Tice spoke on the economic aspects of corrosion losses and on the corrosion problems in connection with steam heating and air conditioning systems. The Inco film "Corrosion in Action" was shown also.

Mr. Tice's participation in the program was arranged through Northeast Region.

•

NACE's Western Region plans to hold two short courses each year. Attendance is not restricted to members of NACE.

Ordnance Association Meets in Fort Worth

The American Ordnance Association at its thirty-sixth Annual Meeting in Fort Worth May 6, heard a talk on the increasing use of lightweight titanium in recent airframe construction, as a replacement for steel and aluminum. Frank H. Vandenburgh, vice president and general manager of Mallory-Sharon Titanium Corporation, Niles, Ohio, said also that titanium's exceptional resistance to corrosion make it a natural choice for aircraft designers, along with its high strength at elevated temperatures.

Fourth World Petroleum Congress Set for Rome

The Fourth World Petroleum Congress will be held in Rome, Italy, June 6-15, 1955. Plenary sessions and the meetings of sections will be held in the congress building of the Rome Universal Exhibition Center. The meeting is intended to facilitate the exchange of ideas among men representing the science, technique and industry of the world's petroleum.

A tentative program has been arranged by the Permanent Council of the World Petroleum Congress, composed of members from the United States, Great Britain, France, Austria, Belgium, Canada, Germany, Mexico, Netherlands, Venezuela and Italy. The program includes social and cultural activities as well as the official meetings. Tours will be arranged to all important industrial centers, as well as to many scenic spots in Italy.

There will be meetings of specialized interest in many fields, such as geology and geophysics, drilling and production, oil processing, transport storage and distribution and construction of equipment, materials and corrosion. The papers, discussions and conclusions will be published in the Proceedings of the Congress, in ten volumes. Requests for additional information about the congress should be addressed to A. A. Muston, Gen'l. Sec'y., Fourth World Petroleum Congress, Roma, Via Tevere, 20, Italy.

Metallurgical Research

Much National Bureau of Standards research in metallurgy concentrated on studies of the corrosion of aircraft alloys —aluminum, magnesium, stainless steel, titanium and others—since 1925 has yielded results of basic importance in aircraft design. The chromic acid anodizing process, developed by the bureau, is now used to protect aluminum alloys from corrosion on all naval aircraft.

Considerable work has been done on the stress corrosion resistance of aluminum and magnesium alloys. The effects of manufacturing and assembling processes—such as riveting, welding and dimpling are also studied.

Case Institute Catalogs Research in Corrosion

Research projects underway at Case Institute of Technology, Cleveland are listed as follows in the Institute's March 1954 directory:

Application of the rotogenerative methods to the study of corrosion characteristics of magnesium alloys. Designed to locate alloys with less local cell action than currently used alloys.

Corrosion of galvanized steel in hot water. Water temperature appears most significant.

Asphalt emulsions, analysis of coal tar pitch, synthetic rubber polymerization studies, oxidation and aging of natural and synthetic rubbers, synthetic paint lattices, dispersion of pigments in aqueous media, thermosetting mastic coatings, accelerated testing of fungicides in coatings, microstructure of pigmented films, mechanism of flake formation in low alloy steels, the mechanics of embrittlement, low temperature embrittlement, embrittlement of alloy steels at high strength levels, a theory of the hydrogen embrittlement of steels, delayed failure of high-strength alloy steels.

Hydrogen embrittlement of high-strength alloy steels, the influence of microstructural constituents upon the mechanical properties of high strength gun tubes, oxidation of alloys, behavior of zirconium in the presence of hot air.

European Chlorine, Caustic Electrolytic Cells Described

A paper presented at the New England Spring National Meeting of the American Institute of Chemical Engineers at the Hotel Kimball, Springfield, Mass., in May, describes European designs of electrolytic cells for the manufacture of chlorine and caustic. Norbert A. J. Platzer, a staff member of Monsanto Chemical Co., is the author. According to the paper 93 percent of present chlorine production is by electrolysis of sodium chloride in "diaphragm" and "mercury" cells. He pointed out certain advantages of the American Hooker cell over the European cell, notably economy of operation. In conclusion he said that current trends were to build the cells as compactly as possible and to produce chlorine with less by-product caustic.

"The Influence of Contaminants on Process Design and Economics" was presented to the meeting by B. J. Mayland of the Gas Process Division of the Girdler Co., of Louisville, Ky. Trace contaminants such as catalyst "poisons," fly ash, sulfur and others which attack the materials of construction used in cracking furnaces and argon gas which has been known to accumulate in certain parts of ammonia plants and throw the process off balance were mentioned in the paper.

Selling a Corrosion Program to Management*

By F. L. WHITNEY, JR.*

Introduction

CERTAINLY selling a corrosion program to management is a comprehensive problem! Judging from numerous discussions and experiences in the field, it is a problem to which no easy answer can be found. While it is evident also that the problem is vitally important and complex, only two elements need be considered. One is the preparation of a well-planned and organized corrosion program carefully spelled out to fit the needs of the particular location. The other is salesmanship—presentation!

But why is it necessary to "sell" a corrosion program to management? Certainly there has been a great deal of representative and pictorial publicity on the devastating and costly effects of corrosion. An estimated annual cost of around 5 to 6 billion dollars due to corrosion should give any scientifically-minded and responsible person pause to reflect. Does his enterprise experience corrosion which contributes to this loss? Could it be reduced? What is he doing about its elimination or reduction?

But what of management's reaction to these facts and this approach to the problem of corrosion?

For simplicity, let the term management include all "bosses" from immediate supervisor to plant manager, or when applicable to members of staff or research departments, from manager to director to executive committee. And because management is people, the action thus is selling to people. Functionally, the subject could be a material object, such as an egg beater or Cadillac sedan, as well as a corrosion program. The job is to convince an individual that he needs, wants, or can use to his profit and enjoyment what is for sale.

While some believe a corrosion program applies only to plants large enough to sustain a formal program, the writer prefers to interpret it more broadly. The idea should in principle at least cover all industrial, research and educational units—large or small. A corrosion control program is important to the salesman, to individuals in technical development, to field engineers and to management alike. The size of the industrial enterprise should limit the endeavor only to the extent of who shall do the work and the elaborateness or formality of the corrosion program.

Certain prerequisites are necessary to achieve maximum effectiveness. They are:

1. That there is a worthwhile service to sell.
2. That corrosion engineering is believed in deeply enough to induce constant work on its promotion and a resolution to be its "best example"!
3. That it is worthwhile to keep pushing forward the development of corrosion science and its application despite technical discouragements or personal resistance and rebuffs.

Poor Presentation—Poor Accomplishment

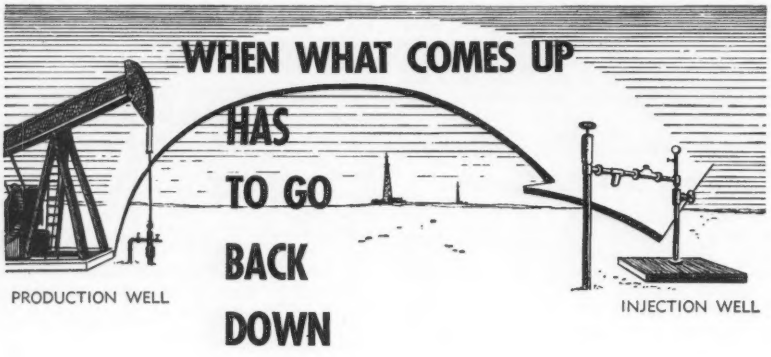
When ideas are not sold the fault often is poor presentation. To sell, to accomplish an objective, the willing and sympathetic help of the listener must be aroused. How many times have bosses been asked for new equipment, more manpower, more money to make new studies? How many times have customers been asked to employ certain materials or corrosion preventive measures? How many times have these requests been successful and how many times failures? Is the blame for failure accepted or is there a tendency to lay the blame on the bosses or customer because they are too cheap, too stubborn, or, to those who are more generous, "they just don't understand"? Why don't they understand? And here is the crux of the problem—understanding is lacking because presentation was poor! Why expect success if understanding and belief cannot be induced?

Therefore, it can be said, doing a good **technical** job is not enough. Presentation must be good too. The writer once worked for a section manager who believed that successful engineering was about 90 percent salesmanship and 10 percent technical ability. These percentages are neither defended nor attacked, but are cited as reflecting the importance one man attached to selling. Poor presentation is a common fault. Months,

(Continued on Page 32)

★ Basis for a lecture at a Corrosion Short Course, Case Institute of Technology, Cleveland, June 19, 1952.

* Monsanto Chemical Co., St. Louis, Mo.



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Selling a Program—

(Continued From Page 30)

sometimes years are spent painstakingly developing sound engineering fundamentals or processes but only a few hours' preparation is considered sufficient for the "selling." The fact that the person who does the "buying" knows little about the problem is overlooked. If the the buyer is to be "sold" in an hour's interview, the presentation has to be good. It has to be prepared for the buyer, aligned with his thinking and mental processes and not organized solely to please the presenter's ego. Nor can it be only a cold, precise and sound technical or scientific dissertation! It must, of course, be sound and logical but that is no reason it cannot be alive, stimulating and convincing also!

Elements of Good Presentation

There is no one specific formula for good presentation. Presentation problems are complex enough to demand at least as much study as a technical problem itself. Many authors have developed principles of effective presentation and while all agree on general principles, details of application vary. The writer recommends strongly that presentation be studied! That it be given the same attention as the technical background of any problem undertaken. One of the best books on this subject known to the writer is that by C. F. Braun.[3] The value of this book lies in its simplicity, clarity and forcefulness. Because of the importance of the subject, a brief review of key elements should be helpful and an attempt will be made to follow these structural elements in developing arguments for selling management a corrosion program.

"Presentation" is, in reality, preparing an "argument" or a "case" for some item on which affirmative action is wanted. The beginning is the idea—when a technical study is complete and ready to present for action. First, write out on paper all arguments pro and con. Become convinced of the practical improvement value of the idea. Remember that up to this point all action has been limited to one person. It is perhaps at this point that most "failures to sell" occur, because many simply present to management the arguments they used to convince themselves.

By changing places figuratively with the person or persons from whom action is wanted, the right point of view may be understood. Arguments should be drafted in a way helpful to the reader or listener in following the reasoning and in gaining understanding by analogy. The listener's problems, experience and mental processes should be willingly considered.

Prepare the project in simple, clear, honest and forceful language. When agreement is achieved state clearly and briefly the action wanted and how the objective may be accomplished. Braun[3] summarizes beautifully this whole process as follows:

"Only as we give Consideration may we expect to get Sympathy"

"Only as we give Clearness may we expect to get Agreement"

"Only as we give Guidance may we expect to get Action."

It should be clear now that the basic and the most important factor in successful presentation or selling is considering "the other fellow"—management—the bosses! Embark then on the task of presenting a corrosion program with this principle as a guide.

The Need for a Formal Program

The "bosses" must be induced first to appreciate the extent to which corrosion engineering has developed. It must be remembered that no matter how convinced the proponent is of the value of corrosion engineering those who are to be sold may not share his convictions. Hence, the first task is to arouse in the listener an interest in, an understanding of and a recognition of the merits of corrosion engineering.

Formerly, the little corrosion work done in the industrial field was by persons inexperienced in corrosion science. They learned by trial and error. However, these workers added their voices to those of a few far-sighted pioneers and researchers who pointed out the advantages of making coordinated studies of corrosion problems and applying scientific principles to them. These pioneers laid the foundations for the growing recognition of corrosion engineering as a formal science, progress in which so far has only lightly brushed the surface of vast fields of industry.

The time is past when industry could afford the waste and delays inherent in the trial and error method. Risks formerly taken must be avoided now because of increased costs and taxes and reduced margins of profit. The necessity for being right the first time is imperative.

If the foregoing conclusions are reliable, a formal corrosion program is necessary. Modern plants in the chemical, petroleum, refinery and allied industries impose stringent demands on materials in producing commodities at low cost and of highest quality. To meet these demands, manufacturers are producing an ever increasing variety of metals and alloys, ceramics, plastics, elastomers and protective coatings. The variety of these materials makes it difficult for design, maintenance, development and process engineers to be sure of selecting a material which will give adequate service at minimum cost. Formerly, because of limited materials and less severe service requirements the field engineer generally could make his own selection with reasonable assurance of obtaining fair performance. Because this is not always possible today most large, modern chemical plants employ a corrosion or materials engineer who, with the necessary assistants, has the responsibility to acquire experience in the selection of construction materials for chemical plant service.

The full value of a formal program does not end with the selection of the material. Sustained effort is necessary to keep abreast of new techniques in fabrication, repair and maintenance of equipment. Continued effort is needed to get and train personnel to inspect and test field equipment so it is always in safe operating condition. In many instances procurement and training of personnel to inspect and evaluate fabricating shops is justified as insurance that equipment manufactured will be well made and that highest quality materials are used to prevent premature failures. Further, today's exorbitant taxes make it necessary to keep capital investment to a minimum. This means production capacity of a plant must be maintained at its highest peak. To assure freedom from unscheduled shutdowns due to failure of equipment, the development of effective inspection and preventive maintenance schedules is a prime requirement. With adequate equipment cost and performance data at hand, it is a natural function of the corrosion or materials engineer to assist maintenance and engineering personnel in developing and recommending these schedules. It is also a natural function for materials engineers to assist maintenance personnel in determining how improved maintenance engineering methods and controls may be developed and utilized.

The foregoing work functions are not new and in many cases probably are not different from those now undertaken in many plants. The major difference proposed in a formal corrosion control program and hence its principal value, is that these functions now distributed among several individuals, logically should be concentrated in one engineer or group of engineers. Furthermore, an understanding of corrosion technology and corrosion engineering and experience are basic considerations. A formal corrosion control program may be narrow in concept or extremely far-reaching, depending upon the size and diversification of the industry concerned. Despite the variety of alternatives, the writer believes they may be summarized into two fundamentals. The first fundamental approach is to stop corrosion before it starts. The second approach embraces maintenance cost reduction studies. These approaches will be considered in sequence followed by arguments for discussion, management's probable opposition (or opinions) weighed and where necessary rebuttals offered to management's points of view.

Approach 1
Stop Corrosion Before It Starts

Stop corrosion before it happens! This should be a good opening argument for promoting a corrosion program with management. F. L. LaQue, in charge of Corrosion Engineering Section, International Nickel Company and formerly president of the National Association of Corrosion Engineers, has used the following example in his discussion on combating corrosion. Civil engineers concerned with bridges are engaged primarily in designing and constructing bridges that do not fail, rather than with explaining why failures occur or with devising ways to patch them up when something has gone wrong!

This analogy makes sense. The idea must have some merit because of its widespread application. This must be the reason many chemical and petroleum plants employ experienced corrosion and materials engineers in functional departments whose basic activity is to recommend materials of construction prior to installation and operation. For example, Shepard[2] indicates that the procedure followed by the American Cyanamid Company in regard to corrosion is to design away from corrosive conditions. He points out that the research chemist and materials engineer start and work together on materials of construction from laboratory to pilot plant or semi-works scale. Their primary objective is to avoid, where possible, corrosive conditions in proposed processes. He illustrates a case in which the use of cuprous chloride was proposed for a process.

(Continued on Page 33)

Selling a Program—

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The corrosion rate on a corrosion resistant metal was in the order of 0.1 inch penetration per year. Substituting copper sulfate for cuprous chloride resulted in corrosion rates on either stainless steel or mild steel which were satisfactory. This method postulates that the corrosion engineer must have a thorough knowledge of chemistry, unit operation, process conditions, design (both chemical and mechanical), metallurgy, methods of fabricating equipment and corrosion technology. Other plants employ other methods.

Perhaps the most common procedure is to find satisfactory materials without altering process conditions. Often conditions are not amenable to alteration for process reasons so a metal, alloy, or other material must be obtained which will meet economically the conditions imposed upon it. The role of the experienced corrosion engineer is no less important when this method is used. The corrosion engineer can determine, by a review of the proposed conditions with the chemist, all factors influencing corrosion. These include trace impurities or contaminants, aeration, temperature, concentrations, agitation, analysis of local conditions and probable types of attack, type of equipment contemplated, including its design, fabrication, castings and wrought components; properties of materials, availability in various forms and sizes, etc. His knowledge of and experience with these factors will enable him to select the minimum number of materials for testing. His experience will help in preparing a test program which will more nearly approximate actual plant conditions, or, at least he should be able to spot danger points in the proposed operations which will require special investigation and special testing programs.

But what about management's reactions to this approach? They are many, but chief among them is the comment "We are already doing this." An investigation will show that they are—just as they did twenty years ago! The chemist, possibly assisted by a process engineer or maintenance engineer and some trade bulletins, is attempting to work out materials of construction. Neither have any appreciable experience in corrosion technology nor an adequate knowledge of the properties of materials, available forms and effects of and proper techniques of fabrication. How can management be convinced this is not good practice? By examples, perhaps? Very well—here are two representative personal experiences.

This incident occurred shortly after the writer was assigned as corrosion engineer at one location. A request came to the division for replacement of existing process equipment with stainless steel at a cost of about $70,000. The project was urgent because it involved quality and sales. The use of stainless steel was questioned because it would be exposed to hydrochloric acid. It was learned that the performance of a stainless steel laboratory reactor was the basis for selection. The research report stated the reactor had lost less than 1 percent of its weight! Furthermore, it was the only stainless steel in the laboratory set-up, the rest was glass. Yet, on

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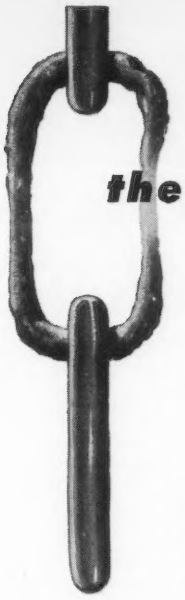

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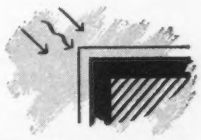

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Selling a Program—

(Continued From Page 33)

the basis of the reactor performance stainless steel was recommended for distillation equipment, separators, receivers and storage tanks! Fortunately, the reactor was still available and examination revealed severe pinhole pitting, particularly in the vapor phase. A plant test on stainless steel in a location believed to be most severe gave a corrosion rate of more than 0.5 inches per year, so a proper corrosion test study in the existing plant equipment was made under guidance of experienced personnel. A satisfactory material was found which not only performed well under actual conditions, but also contributed to a yield increase. Thus a possible $70,000 loss was turned into a savings of many thousands of dollars.

Another incident concerned the selection of stainless steel on the basis of corrosion rate data only. Equipment costing more than $50,000 was fabricated and installed. It failed after two weeks of service because of stress corrosion cracking! This tragic waste could have been prevented. The susceptibility of stainless steel to stress corrosion cracking in this particular environment would have been known to an experienced corrosion engineer.

These are only two of a legion of such examples. While experiences of this kind probably make an impression on those concerned, what about those who have had no such experiences? What about those who have continued to "get by" in the "old way"? They probably have high costs also, but these costs aren't so apparent. Are these examples—this method alone—sufficient to "sell" a corrosion program to those "getting by"? It is unlikely. Another approach is needed. If eliminating duplication of effort, wasted time, questionable results and small errors are not convincing, then something else must be offered.

Approach 2
Maintenance Cost Reduction

The second major approach is through potential maintenance cost reductions. This phase has multiple opportunities, large potential savings and many means of achievement. One purpose of a corrosion engineering program may be cost reduction by the use of improved materials and better design, fabrication, repair and maintenance techniques. In addition to reductions in maintenance costs, savings through reduced taxes and overhead charges may be achieved by the application of corrosion engineering principles to produce products of higher quality and at higher production levels. Improved safety or operation may be a source of savings. A central materials testing laboratory is another potential source of savings.

Where corrosion is involved, equipment and design standards should be set up by the corrosion engineer, or at least with his help. In the past this important subject often has been treated summarily as a matter of statistics with studies conducted largely by clerks and draftsmen.

Where corrosion is involved, simple statistics are insufficiently indicative. For example, based upon experience in the field, a materials or corrosion engineer is assigned to establish standards on valves for sulfuric acid service. During the course of his study he will find different makes, different designs and different materials of construction used for the same service in different areas and departments. He will study service life, frequency and cost of packing, the spare parts inventories in the stock room and evaluate all factors on an annual cost basis. If records are not available (and this means records, not guesses) a temporary system may be set up to get data. He may find one material of construction best instead of three, that possibly two makes of valves instead of four and that two types of design instead of six are sufficient. Net result—lower initial cost from improved service life and large lot buying, smaller spare parts inventories with attendant lower overhead costs. He may even find one department in which performance is poorer with the limited valve selection, but the over-all savings justify the simplification. The extent to which standards may be applied is essentially unlimited. Pipe, tubing, fittings and pumps are "naturals" for standards.

Design standards for corrosion service are also important. Standards of fundamental design, fabricating techniques and selection of materials have been established but many designers and draftsmen do not seem to be aware of them. Adequate standards may be established by engineering staffs in consultation with the corrosion or materials engineer to prevent repetition of common errors. Such standards also will assist design, project, process and maintenance engineers in preparing design sheets, cost estimates and projects more quickly and with less danger of selecting inferior or more costly materials than necessary.

Cost Records Are Fundamental

The key to a sound materials or corrosion engineering program, operating on a cost reduction basis, is an adequate equipment cost and performance record system. Yet when this subject is mentioned a blank wall is often struck. The common vision seems to be one including hordes of clerks and tons of paper! Nothing could be further from the truth! All plants have a system for accumulating maintenance costs so monthly cost sheets may be computed. Basically, all that is required is the circulation of, or another copy of, the requisitions, work orders, etc., which are used to make up the cost sheets. Equipment records are usually kept for design and capital investment purposes. Oftentimes a combination of equipment record, performance and costs on one card is simplest.

Some additional data may be required. How much, depends upon the elaborateness and scope of the system. A word of caution, design the system to fit the need, don't let the "tail wag the dog"! Accurate costs and performance records are the lifeblood of a corrosion program. Don't try to save money by half measures. Inadequate records cannot be used as a basis for a sound and economical solution. It is like trying to prescribe a material for use in an unknown environment.

The writer personally has observed in many instances the value of good records. But one of the most forceful examples was heard at a talk on preventive maintenance. At the Chemical Session, Central States Safety Conference, May 28, 1952, J. J. Duggan, Head, Fire Protection Engineering Staff, Union Carbide and Carbon Corporation, gave a paper on "An Equipment Preventive Maintenance Program." To illustrate the value of cost records, he cited a condition concerning pump maintenance in one department which was apparently accepted as normal. When records were established they revealed an annual expenditure of $18,000! This sum was equivalent to the cost of 18 new pumps a year!

Materials Testing Laboratory Is Valuable

In larger industrial plants, particularly those manufacturing a wide variety of products, a central materials testing laboratory often may realize savings in time and money, as well as other intangible benefits. Primary objective of a central laboratory is the development and use of uniform test procedures and equipment for materials evaluation, selection and quality control. These methods are designed to bring tests under central control in a plant to produce reliable and reproducible results. Methods are also developed to provide short-time evaluations to eliminate if possible lengthy and sometimes costly plant tests and shutdowns. Controlled procedures of this kind together with experienced personnel, eliminate the danger of obtaining unreliable results frequently resulting when tests are conducted in various laboratories or departments by inexperienced personnel.

The laboratory also should have special testing equipment, such as an erosion-corrosion tester. The value of this equipment may be illustrated by the following example: Materials of construction usually are evaluated in the plant or laboratory under essentially static conditions. Data thus developed are used for valve and pump service criteria in full knowledge that service velocity conditions are not comparable to test conditions. The erosion-corrosion tester is capable of approximating design conditions, so that in an 18-hour test, reliable corrosion data under both static and dynamic conditions are obtained simultaneously.[3] Costly failures resulting from velocity thus may be averted. Another merit of this equipment is in its ability to test the process materials obtained from the plant with savings in time, money and shutdown time when field tests are unpractical.

The Factual Presentation—
Its Limitations

For instance, approach the manager of a large plant of diversified chemical operations and present the foregoing examples in describing the merits and value of a corrosion program. Point out to the manager the magnitude in dollars of his annual maintenance bill and that formal corrosion programs at other plants have realized tangible cost reductions of ranging from 10 to 25 percent of the annual maintenance bill. Explain that for his plant this saving would be large, one which amply justifies a formal corrosion program. This would certainly seem to be the factual approach! It is made under the impression that such figures will secure management's immediate attention and sympathy, because facts are given—costs—management's yardstick of performance. In most cases this argument is convincing.

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Selling a Program—

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But some are not impressed! One is skeptical and opines he does not wish to engage in such work "just now"! No matter that this may be a "leaky roof" policy and no matter how right the proponent may be, nothing will be done because management has not been "reached." There is an impression among engineers and business men that facts speak for themselves. Braun[1] says this is "pure nonsense, as every lawyer knows—they are useless unless they have a champion to talk for them, to fight for them." The writer believes this, but he also believes the fight must be on the opponent's ground. But to do so successfully the real reason for management's resistance to the facts must be known. Whether it is due to inertia, resistance to change, more pressing plant problems, or fear and suspicion must be determined.

The writer believes the most common reasons for inaction are inertia and resistance to change. Everyone has a natural reluctance to "stir his stumps." Particularly is this true if there is a conviction that an adequate program is already "on paper" if not in being. There is a natural reluctance to spend one's own money to save money. Let each one analyze his own personal inertia and spending habits and he may get a fair idea of the obstacles to be overcome in selling management. Fear of usurpation of responsibilities of engineering and operating supervisory functions by the corrosion engineer often is expressed. Nonsense! The trained corrosion engineer will assume the burden of "doing" and allow incumbents to "supervise." They will have more time to think creatively and suggest methods of attack on their problems. As a matter of fact, their responsibility will actively increase. Theirs is still the responsibility to weigh and decide. Theirs is still the decision to accept, to realize the savings and recognize the improvement. It is the corrosion engineer's responsibility to get the facts, to conduct the work properly and to provide the experience so a logical and scientific evaluation may be made.

Fear and suspicion are real reasons which can be overcome in some individuals by sharing knowledge with them. It often is very difficult to evaluate this factor. The writer doubts it is recognized by the individuals themselves. Fear and suspicion are generally the result of lack of knowledge.

The following illustration is appropriate. The electrical lineman is constantly exposed to hazardous high voltages—exposures that can be fatal. He does not "fear" the electricity—his knowledge of its power makes him "respect" it.

The program should be sold by showing it fits the "boss's" prime interests. Remember to key arguments to the interests of management. Find its prime interest. If it is production, perhaps the best argument is to explain the role of the corrosion engineering in improving quality, preventing lost production due to unscheduled shutdowns or lowering costs through improved materials of construction. Other problems also beset "bosses," for example, policies, labor, development, research. The more the program is fitted into management's

(Continued on Page 36)

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Selling a Program—

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thinking, the more likely the presentation is to succeed.

Old Methods Still Prevail

Others may say the corrosion program is already the responsibility of the engineering staff or the operating supervisors. The statement is made: "They know the operations best—they are more cognizant of our needs than an outsider." In this latter instance the prejudice goes even further than preoccupation with production. Operating supervisors are supposed to be not only experts at corrosion and materials engineering, but experts on design, distillation, heat exchange and all other engineering unit operations simply because they are more familiar with the operations. Pointing out inherent dangers in this point of view will not do much "selling." These attitudes may be firmly established and must be combated honestly and sincerely.

The competent corrosion engineer must have a wide knowledge of design, fabrication, properties of materials and processes. Thus, he is the best one to head a team to solve corrosion and materials engineering problems. He can attack a problem in many ways other than through materials selection. His approaches also include design, fabrication, selective use of the properties of materials and process change. The operating man or laboratory technician's approach is, because of inexperience, limited to process knowledge. The corrosion engineer working with operating, maintenance, research and other personnel helps to make a good team to get the best solution.

Research departments often pay little attention to solving materials problems for new processes because their primary objective is, of course, the development of processes. The department feels design and materials of construction are jobs for another department. Sometimes, however, interest is evidenced in the probable performance of a particular material in a part of the process to the extent of making a short laboratory test on a material of assumed, but unknown, composition. The results are reported in the research report simply as a weight loss determination or corrosion rate in inches per year with no description of conditions. Can this be called "metals testing"? A more unreliable basis hardly could be selected. If the test was worth making, it was worth doing right. Results of a test of this kind should not have been reported. A useful report will give conditions of test and other details so its value can be weighed.

S. D. Heron, in the introduction of Gillet's[4] report on the evaluation of metallic materials, touches upon these attitudes. He claims one individual seldom is simultaneously an expert in design, in metallurgy and in testing and that it is undesirable to take a good design engineer's time and seek to turn him into a poor metallurgist or vice versa. He further believes that too frequently the reference book is resorted to as a solution to a material selection problem and that insufficient time is given to the matter or to consulting with qualified persons. The corollary: What is achieved by trying to make good operating supervisors and maintenance engineers into poor corrosion engineers? This question is particularly apropos when an activity requiring a high degree of technical knowledge and experience is assigned to persons without these qualifications as only one of numerous duties.

The petroleum and refining industries have recognized the need for engineers with specialized training. This training is presently an important and very active point of discussion between industry and educational institutions. While complete agreement on how specialized training shall be attained is not yet reached, there is agreement on the need. Why? It can only mean that current general training of the chemical engineer is inadequate to meet many specialized industrial demands. It is interesting to note that Gibbons[5] in his article "Is Specialized Engineering Needed?" puts the need for corrosion engineers second only to the need for refinery engineers in a long list of specialized engineers needed by the refinery industry.

What Is a Corrosion Engineer?

Some people feel that corrosion engineering is in a dead end job, while others feel that corrosion engineering is metals testing in its simplest sense. During a recent discussion of a proposed formal corrosion program, a comment was made that the idea was fine, but that the corrosion job was a "dead end"! "What is to be done with the person upon completion of the job? He is a 'specialist,' and therefore, of little value elsewhere." In another instance the opinion was advanced that corrosion studies are simply "metals testing," do not require any particular skill and do not warrant using a valuable engineer's time. What a challenge, what a wonderful opportunity to improve the understanding of what a real corrosion program can do! Impressions such as these of a corrosion program prompt the selling of a broader coverage, materials engineering, the basis of which is corrosion. Corrosion technology, per se, is indispensable, but its application in the broader aspects of the engineering art has more far-reaching potentials in cost reduction studies.

Thus far in this discussion proposals for management have been suggested, its views and opinions considered and replies given to management's views and opinions. So, assume consideration given and sympathy obtained. Clearness is given and agreement obtained. Now guidance must be provided to insure action. In a general article this is not easy. Much depends upon analysis of the leaders of the organization, plant policies, technical manpower situation and potential cost reductions to be achieved. The writer believes the best that can be done is to present an outline to be used as a guide. The "salesman," must adapt and prepare the details for the particular circumstances. It is a cooperative venture between management and field personnel.

How May a Corrosion Program or Materials Engineering Program Be Established?

Suggested below is a method for initiating a materials engineering program. It assumes a decision has been made to proceed with such a program. Hence it suggests the various steps that might be taken.

I. Selection of Individual

Management may wish to consider selecting the corrosion engineer by one of the following methods:

1. Assign an experienced plant man, preferably a chemical engineer and train him in materials engineering as the program develops.
2. Employ a trained corrosion or materials engineer. Permit him to gain plant experience as the program develops.
3. Employ a graduate engineer, preferably a chemical or metallurgical engineer and train him in materials engineering. Permit him to gain plant experience as program develops.

II. Introduction of Program

Management meets with department superintendents to:

Briefly discuss the purpose and potential scope of the cost reduction program.

Introduce the materials engineer if necessary.

Point out that cost records and equipment performance records are the fundamentals for a sound, aggressive approach. Enlist production and engineering's aid to keep records clearly, accurately and up to date. Existing cost systems may be used initially and modified if necessary.

Stress the danger of spreading activities too thin. Discuss with superintendents the value of concentrating at the start in the area or department believed to have the highest maintenance costs per capital dollar or per unit of production, whichever is the best yardstick of cost performance.

Decide which location will be the starting point and concentrate activities in this area. Expand the work and scope as conditions warrant.

III. The Materials Engineering Program

If an engineer is selected with no background in materials engineering or chemical process corrosion, it is necessary first for him to acquaint himself with the factors involved in the investigation of field problems. Possibly opportunities may be provided for him to attend corrosion short courses offered by universities or to attend extension classes in corrosion and materials engineering. In the interim he may start his program as follows:

Study the present cost records and equipment performance records.

Establish a means whereby these records are made readily available and of maximum use to the materials engineer, maintenance engineer and production. Consider improvements to the present system, but hold off any revisions until justification is clear and timing is right.

Study maintenance costs in the area or department selected.

Study equipment failures in the field and segregate them by type, such as corrosion, mechanical faults, design, operation, etc.

Review these items with production and maintenance supervisors and agree to study first those which will improve production quantity or quality or decrease maintenance costs most. Estab-

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lish a priority schedule based upon importance of the work and magnitude of savings. In case of conflict in priority of studies, management may decide the proper order.

Initiate each study in some such sequence of events as listed below:

1. When the cost and service performance of the equipment are known, consider materials and methods which will give better service and weigh probable costs on an annual basis. If actual experience is available which indicates the use of a material to be profitable, make the replacement direct. If this procedure is inadvisable, make plant tests with small parts fabricated of the material, such as pipe sections, pipe fittings, valves, etc.
2. If no experience with the improved material is available, make plant tests using standard specimens. Exposures should be made in that part of the process representative of the most severe conditions. Evaluate results in terms of a complete replacement and select that material which gives the lowest annual cost or meets best some other vital production requirement.
3. If plant tests cannot be made, set up laboratory or pilot plant tests which will most nearly approximate plant conditions. Intricacy of the problem and magnitude of the savings may determine the elaborateness of the experimental work.

From repair cost records establish repetitive frequencies and develop with operations and maintenance schedules of planned shutdowns, inspections and repairs before breakdowns occur. These schedules may be established on an annual basis or other practical operating periods. When these schedules are satisfactorily established, they may serve as a basis for estimating crew and craft requirements for the area. They may also help in budget preparation and control, maintenance performance other than cost and preventive maintenance studies.

IV. Management Control

The writer believes corrosion or materials engineering is a management tool because it can be so valuable in cost reduction. This is true because application of the program affects and requires cooperation of the production, engineering, research, safety and accounting departments and because decisions affecting the whole must be made which cannot rightfully be made by a single department. What and how extensive this control should be is management's prerogative. But the writer also believes management has an obligation to the materials engineering function—to know at all times its justification; to rectify, if possible, conditions of inadequate performance and to discontinue it if facts show it to be an unjustifiable venture.

Although this may be "treading on thin ice," personal observation prompts this suggestion. Consider carefully the designation of responsibility for this function. If placed too far "down the line," without an adequate "ear" and bound in "red tape," initiative and performance may be of a low order. The writer believes supervision high in the

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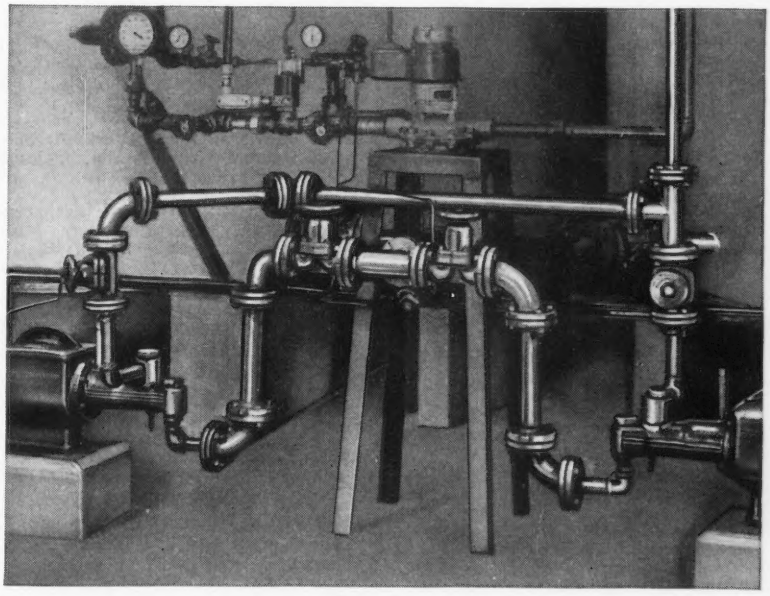

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CORROSION MEETINGS CALENDAR

July

11-14 American Society of Refrigerating Engineers, Hotel Olympic, Seattle, Washington.

Sept.

1-16 International Electrotechnical Commission, Golden Jubilee Meeting, University of Pennsylvania, Philadelphia, Pa.

8-10 Pacific Coast Gas Association, Victoria, British Columbia.

12-16 American Institute of Chemical Engineers (National Meeting) Hotel Colorado, Glenwood Springs, Colo.

28-29 Texas Mid-Continent Oil and Gas Association, Baker Hotel, Dallas, Texas.

Sept. 28-Oct. 1 Iron and Steel Exposition, Cleveland Public Auditorium, Cleveland, Ohio.

Sept. 29-Oct. 1 Porcelain Enamel Institute, Annual Meeting, The Greenbriar, White Sulphur Springs, West Virginia.

Oct.

3-7 The Electrochemical Society, Fall Meeting, Boston, Mass.

11-14 American Gas Association, Annual Convention, Atlantic City, New Jersey.

11-15 American Institute of Electrical Engineers, General Fall Meeting, Hotel Morrison, Chicago, Ill.

12-15 National Association of Corrosion Engineers, South Central Regional Meeting, Dallas, Texas.

17-23 American Society for Metals (National Metal Congress and National Metal Exposition), Hotel Statler, Cleveland, Ohio.

28-29 American Society of Mechanical Engineers (Fuels-AIME Coal Conference), Hotel William Penn, Pittsburgh, Pennsylvania.

Nov.

1-3 American Institute of Mining and Metallurgical Engineers, Institute of Metals Division, Fall Meeting, Sheraton Hotel, Chicago, Ill.

1-5 National Metal Exposition, Chicago, Ill.

8-11 American Petroleum Institute, Conrad Hilton Hotel, Chicago, Ill.

15-18 American Gas Association, Operating Section, Organization Meetings, Hotel New Yorker, New York,

28-Dec. 1 American Society of Refrigerating Engineers (50th Annual Meeting), Hotel Ben Franklin, Philadelphia, Pennsylvania.

28-Dec. 3 American Society of Mechanical Engineers (Annual Meeting), Hotel Statler, New York, New York.

Dec.

12-15 American Institute of Chemical Engineers (Annual Meeting), Statler Hotel, New York, New York.

1955

Feb.

16-18 National Association of Corrosion Engineers (Sixth Annual Pipeliners Short Course) Mayo Hotel, Tulsa, Oklahoma.

May

1-14 American Institute of Chemical Engineers, Shamrock Hotel, Houston, Texas.

9-13 A.G.A. Industrial Gas School—(location to be announced).

16-18 Southern Gas Association, New Orleans, Louisiana.

June

5-9 Canadian Gas Association, Annual Meeting, General Brock Hotel, Niagara Falls, Ontario, Canada.

12-17 American Water Works Association Annual Conference, Chicago, Illinois.

13-18 American Society of Mechanical Engineers (75th Anniversary Meeting), Congress and Hilton Hotels, Chicago, Illinois.

Oct.

17-19 A.G.A. Annual Convention, Los Angeles, California

17-21 National Metal Exposition, Detroit, Michigan (A.G.A. will exhibit).

Nov.

13-18 The American Society of Mechanical Engineers, Congress & Hilton Hotels, Chicago, Illinois.

27-30 American Institute of Chemical Engineers (Annual Meeting), Statler Hotel, Detroit, Michigan.

1956

Oct.

15-16 National Metal Exposition, Philadelphia, Pa. (A.G.A. will exhibit).

29 to Nov. 1 A.G.A. Annual Convention, Atlantic City, New Jersey.

Nov.

25-30 The American Society of Mechanical Engineers, Statler Hotel, New York, New York.

1957

Oct.

21-25 National Metal Exposition, Cleveland, Ohio (A.G.A. will exhibit).

ACS Petroleum Research Grants Are Available

The American Chemical Society is now prepared to make grants for research in the petroleum field from the $1,000,000 research fund set up some years ago for administration by the society. The grants will be made by the society's board of directors to persons recommended by the Petroleum Research Fund Advisory Board under the chairmanship of Dr. Cary R. Wagner of Utica, Ohio.

Selling a Program—

(Continued From Page 37)

plant organization levels is most effective.

Conclusion

In this paper an attempt has been made to follow the elements of good presentation as a means to successful selling. An attempt has been made to present the subject to management on the basis of its interests—its opinions—its probable needs. An attempt to foresee some of management's arguments and points of view and to provide answers thereto also was made. In conclusion, it is believed the pattern is logical and appealing. The details are up to the ingenuity and creativeness of the individual corrosion or materials engineer.

Acknowledgments

Appreciation is extended to the following for their courtesy in reviewing and providing helpful suggestions in the preparation of this paper: F. L. LaQue, Head, Corrosion Engineering Section, The International Nickel Company, Inc., 67 Wall Street, New York, New York; R. E. Lenz, Assistant to the Director, General Engineering Department, Monsanto Chemical Company, 1700 South Second Street, Saint Louis, Missouri; Ivy M. Parker, Plantation Pipe Line Company, Atlanta, Georgia; C. B. Roen, Chemical Engineer, General Development Department, Monsanto Chemical Company, 1700 South Second Street, Saint Louis, Missouri.

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5. E. F. Gibbons. Is Specialized Engineering Needed? *Petro. Proc.*, **7**, No. 5, 615-619 (1952) May.

Research Investigations Underway at Stanford

Stanford Research Institute during its seven years of existence has done $18,000,000 worth of contract research. Studies are under way to improve the oxidation resistance of graphite to make its excellent thermal shock resistance available in applications where oxidation can take place. The annual report also describes many other fields in which work is being carried on.

A special report has also been issued by the Institute concerning its Industrial Air Pollution Laboratory. The studies at the laboratory have so far cost almost $2,000,000. A conclusion reached in the report is that the time to act is before the damage is done. "Management should make air pollution part of its thinking . . ." New ideas and techniques are being developed for attacking air pollution and industry may now avoid many air pollution situations before they take place.

NEW PRODUCTS – Materials – Service – Literature

Catalog 54 of the M. B. Skinner Co., South Bend, Indiana, has just been issued. In addition to being a valuable source book of information on the repair of all types of leaks in water, steam, gas, oil, ammonia and brine lines, it lists the entire line of pipe repair equipment sold by the company.

●

Kel-F-Coated o-rings are now being produced by Bacon Industries, Inc., of Watertown, Mass. The silicone rubber rings are highly resistant to aromatic, chlorinated or other solvents, but have a useful temperature range from —120 degrees F to 390 degrees F, according to the company.

●

Titeflex Quick-Seal Coupling, a 16-page booklet released by Titeflex, Inc., of Springfield, Mass., describes a new leakproof, quick connecting or disconnecting hose coupling for water, oil, steam, gas and chemical lines. The simple construction of the coupling provides a unique sealing action, making the coupling tighter as internal pressure increases.

●

Nine Red Lead paint formulas for railroad structures and rolling stock are given in Red Lead Technical Letter No. 8, published at 420 Lexington Ave., New York 17, N. Y. The formulas are intended for steel with mill scale and residual rust (slow dry), steel with mill scale and residual rust (accelerated dry) and steel completely free of mill scale and rust (fast dry).

●

Heat Resistant and Corrosion Resistant Alloy Castings in Industry, bulletin A-141 of the International Nickel Co., New York is a 48 page, illustrated publication intended to point out some of the applications in industry of heat and corrosion resistant alloy castings. There are over 175 photographs, along with charts and other data including a graph of resistance to elevated temperatures, a comparison of creep strengths and corrosion test results.

●

The Dorfan Impingo Filter controls fumes, dust and smoke by a unique moving granule principle according to an announcement by Mechanical Industries, Inc., 942 Grogan Building, Pittsburgh, Pa. The filters are recommended by the manufacturer for use in controlling fumes or smoke in coke quenching operations, electric steel furnaces, dryers of all types and other installations where high temperature, moisture or corrosive conditions are present.

●

Bakelite Company, a Division of Union Carbide and Carbon Corporation of 260 Madison Ave., New York, N. Y., has announced the development of two new epoxies, intended to be combined with four new hardeners to form strong, lightweight products with excellent chemical resistance and electrical properties. The new monomeric, low molecular weight diepoxies, BR-18774 and BR-18795 are described as rapid hardening, thermosetting resins when formulated with their complementary hardeners—BR-18793, BR-18803, BRR-18812 and BR-18807 which are aliphatic polyamines giving the new epoxies a wide range of curing speed, viscosity and pot life.

●

MW Plasticote, an insoluble cement lining to protect the inside of both old and new hot water tanks and generators against corrosion is the subject of a bulletin now available on request from the Protective Coatings Division of Metalweld, Inc., Philadelphia, Pa.

●

Corrosion Control of Electrical Structures and Equipment, a 20-page circular issued by Subox Inc., Hackensack, N. J., describes methods of corrosion control and practical painting information on all phases of transmission and distribution work. Free copies are available from the company.

●

Simplex general catalog of measuring and control equipment has been revised. the 36-page bulletin 004 lists all Simplex equipment for the measurement and control of liquids and gases. For a free copy address the Simplex Valve & Meter Company, 68th and Upland Sts., Philadelphia, Pa.

●

Graph-I-Tite is the name of a material of construction designed for use by the chemical and metallurgical processing industries said to be impermeable, not wetted by molten metals or salts, to withstand effects of the sharpest corrosives and to be suitable for use at operating temperatures up to 5700 degrees F. The material is currently available in a Grade-A and a Grade-G, for low and high temperatures respectively, according to the Graphite Specialties Corporation of Niagara Falls, N. Y.

●

Falls Industries, Inc., Aurora Rd., Solon, Ohio, has announced development of a new impervious graphite rupture disk. The disk is described as an easily replaceable, expendable pressure relief device for protecting closed vessels and systems carrying highly corrosive fluids and gases and is designed for applications in the chemical, pharmaceutical and petroleum processing industries.

●

Spray Gun Motion Study, a booklet published by the DeVilbiss Company, Toledo, Ohio, describes techniques of spraying various surfaces in production spraying operations. Reduction of cost, waste and fatigue in production painting is the purpose of the booklet which is available free from the company.

●

Graver Water Conditioning Co., a division of Graver Tank & Mfg. Co., Inc., 216 West 14 St., New York, N. Y., has published a bulletin on demineralizers. Among topics covered are the proper types of piping and fittings in a demineralizing plant for avoiding deterioration and operating problems due to the products of corrosion.

●

Mathematical Computing Service, an applied mathematics consulting agency, specializes in performing services for industries desiring engineering calculations, charts and nomographs of high complexity and related mathematical problems in the field of chemical engineering. For further information address Mathematical Computing Service, 67-24 211 St., Bayside, N. Y.

●

Fansteel Selenium Rectifiers, a new 24-page booklet, has been published by Fansteel Metallurgical Corp., North Chicago, Ill. The booklet includes information concerning: standard cell sizes and ratings; typical rectifier circuits, formulae and constants, elementary operating principles, installation and care and typical applications with circuit diagrams. Copies are available on request.

●

Hamer Oil Tool Co., 2919 Gardenia Ave., Long Beach, Calif., has changed its name officially to Hamer Valves, Inc., in order to identify the company more clearly with the products it manufactures.

●

Alcoa's Lafayette, Indiana works has installed the world's largest press for the extrusion of metal, the company's bulletin states. The 14,000-ton press will produce light, strong, low-cost aircraft parts for the U. S. Air Force. Parts produced by this press will substitute for aircraft sections that formerly had to be assembled from many small components. The press was built in Germany and originally intended for use in the second World War, but was not finished in time. It was completed by the Schloemann works of Dusseldorf, Germany and bought by Alcoa for shipment to this country. Additional information is available from the company.

●

American Chemical Paint Co., Ambler, Pa., is producing a new protective coating chemical, brush "Alodine" No. 1200, said to greatly improve the corrosion-resistance of unpainted aluminum and forms a durable bond for paint. The chemical is applied manually and meets the requirements of Military Specification MIL-C-5541.

●

Parker Rust Proof Co., Maywood, Cal. has started its third major expansion in four years. The company will have increased storage facilities for raw materials and finished products, a 20 percent increase in manufacturing capacity and added operating efficiency and safety for employees when the project is completed.

●

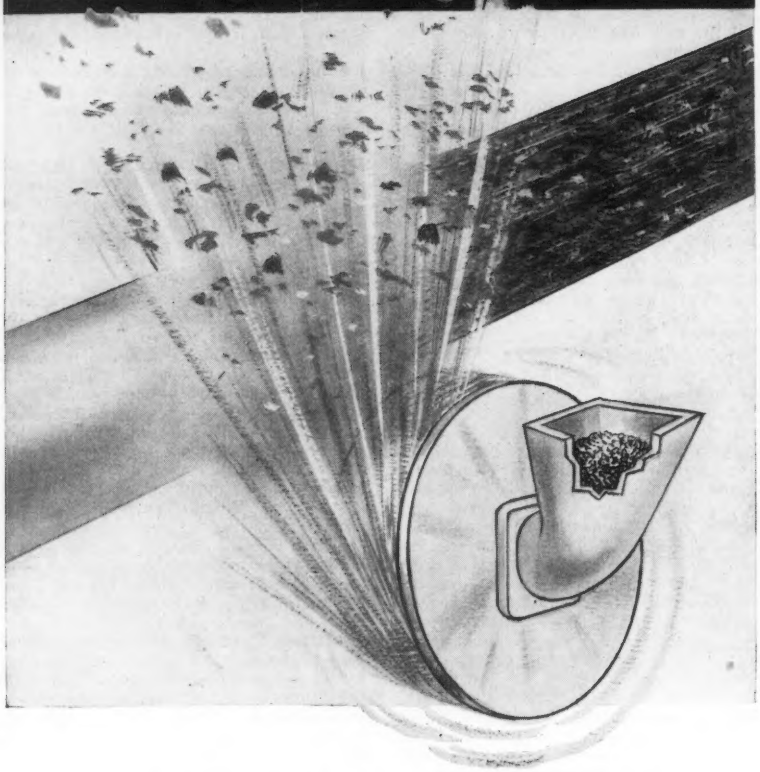
Ebasco Services Inc. has opened a Dallas office in the Southland Life Bldg. to acquaint new clients with the many services Ebasco offers business and industry. The engineering, construction and business consulting firm now has offices in New York, Chicago, Washington and Dallas. The new office will be managed by W. A. Buchanan.

●

Solar Aircraft Co., San Diego, Cal., is distributing a brochure describing ceramic coatings for protecting metals. It presents the uses and properties of Solaramic coatings, a family of proprietary ceramic coatings specially designed to protect high or low allow steel fabrications from heat or corrosion.

(Continued on Page 40)

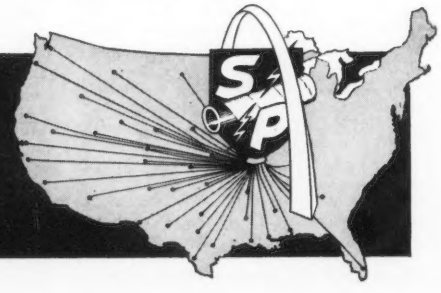
EVERY PIECE OF PIPE IS STEEL GRIT CLEANED AT spi



Standard Pipeprotection Inc. is the only pipe c/w plant to use steel grit cleaning on **every piece** of pipe regardless of size. Steel grit cleaning is used because it produces the perfect surface to bond the coatings to the steel. Bond performance, over the years, cannot be inspected visually or electronically.

WHY PAY THE SAME FOR LESS?

THROUGH FREIGHT RATES AT THE ST. LOUIS GATEWAY



standard pipeprotection inc.

3000 SOUTH BRENTWOOD BLVD. • ST. LOUIS 17, MISSOURI

NEW PRODUCTS

(Continued From Page 39)

General Ceramics Corporation, Keasbey, New Jersey, has developed a new line of Armored Porcelain Centrifugal Pumps which it says is a great improvement over previous pumps. The erosion and corrosion resistance of high strength fully glazed porcelain is combined with the ruggedness of heavy cast iron and armor and a mechanical type seal of proved design is standard equipment. A four page brochure is available from the company.

•

United States Hoffman Machinery Corp., Syracuse, New York, has produced what it claims to be the world's largest magnetic separator tank of 19,300 gallon capacity. Capable of removing 75 percent or more of ferrous solids, the tank is fully automatic, self-cleaning and is equipped with temperature control steam coils. Additional information is available from the company.

•

A Magnetic Permeameter of high sensitivity has been developed by American Instrument Co., Inc., Silver Spring, Maryland. The instrument may have application in the aircraft industry to help prevent exhaust system failures. It is said to locate and evaluate heat corroded areas, separately measuring thermal breakdown and erosion thinning, measures the thickness of metal at any point on the exhaust system, helps to identify metals, measures thickness of non-magnetic and slightly magnetic sheets up to ½-inch thick and measures the thickness of non-magnetic coatings on steel. Detailed information is available on request.

•

Nickel Steels in construction of bridges are described in a 36-page booklet available from International Nickel Co., Inc., 67 Wall St., New York, N. Y. Bridges located in industrial areas or other regions where corrosion is a problem may have their paint life extended 20-50 percent by the use of high strength alloy steels, the booklet says.

•

Unichrome Series 4000 and 5300 Plastisol Compounds produce coatings or moldings combining the best features of chemically inert vinyl plastics and rubber according to a four page bulletin now available from United Chromium, Inc., 100 E. 42 St., New York, N. Y.

•

A Low-Cost Digital converter, smaller than a desk telephone, called the Digi-Coder, has been introduced by the recently-formed Data Reduction and Automation Division of Fischer and Porter Co., Hatboro, Pa. It is designed to convert the analog output of primary sensing devices—such as flow meters, thermocouples or pressure transducers, etc.—into a digital signal. The converter can operate at speeds up to 5000 counts per second. Applications for this device are expected in oil refineries, chemical plants, power plants and in all test, research and computer installations which must process large masses of data.

•

Murphy and Miller, 1322 So. Michigan Ave., Chicago, Ill., has announced a new line of compact, portable and inexpen-

(Continued on Page 41)

NEW PRODUCTS

(Continued From Page 40)

sive enviromental test cabinets featuring a unique sloping front design. The self-contained cabinets are ready to be plugged into any 110-volt connection and are available either as single units, or in any combination to meet specific requirements of low temperature, high temperature, humidity or fungus cycles.

●

Barrows Porcelian Enamel Company, of Cincinnati, Ohio has developed a new joining method for porcelian enamel lined pipe, which it claims will open up wide fields of application in industry. The new method uses a porcelian enamel coated insert of light gauge metal and was developed to combat the effects of high temperature chlorine in an aluminum flusing operation. Additional information about the new product is available from the company.

●

Research at **Alcoa,** a 54-page bulletin just released by the Aluminum Company of America, Pittsburgh, Pa., describes the work of Aluminum Research Laboratories and provides a useful bibliography of technical articles about aluminum. The two color bulletin is available on request from the company.

●

Deuber Laboratories, "an independent service organization dealing with industrial products" has issued a new folder describing its facilities and services available in its laboratories. Pipe coating performance test and related corrosion problems are emphasized in the folder which is available free from Deuber Laboratories, 114 East 32 St., New York, N. Y.

●

The special-formula, inert glass developed by Glass Fibers Inc., of 1810 Madison Ave., Toledo, Ohio, for exclusive use in Blue Flag Pipe Wrap is stressed in a new four-page brochure now available from the company. The brochure contains test data on penetration ratios for reinforced and unreinforced enamels.

●

Andrews-Knapp Construction Company, Inc., of New York City, opened a new base of operations at Sisterville, W. Va., in May. The growth of industry in the Ohio River valley is the reason for the move, according to a company news release. The company produces lead clad steel and copper which are used extensively in the chemical industry as process equipment where severe corrosion is present. These products are also used in the nuclear industries as radiation shields, the bulletin states.

●

International Metal Hose Company has announced completion of its new expansion program at its plant located at 4445 Humbolt St., Detroit, Mich. The company can now supply International Metal Hose in three types: Type B—lightweight; Type BB—medium weight and Type C—heavy weight. Flexible hose is now available in galvanized steel, brass, bronze, stainless steel and aluminum.

●

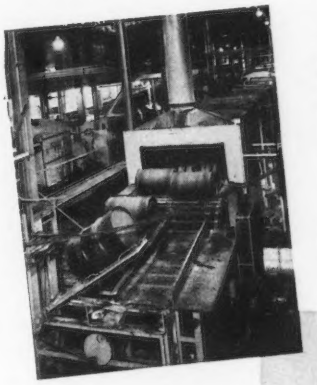
Large Scale chemical and process equipment made of rigid unplasticized polyvinyl chloride will soon be produced by Knapp Mills, Inc., of New York. There has been considerable successful use of

(Continued on Page 42)

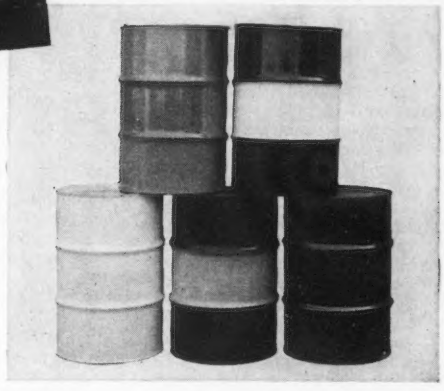
UNITED STEEL DRUMS ARE Granodized WITH GRANODINE®

FOR EXTRA PROTECTION

Steel Drums made by United Steel Barrel Company of Philadelphia, Pennsylvania, are chemically cleaned and phosphate coated in an integrated spray Granodizing process:



1. **ALKALI CLEANING** removes oil, grease, fingerprints, hand-marks, other surface soil;
2. **SULFURIC ACID PICKLING** then removes mill scale;
3. **GRANODIZING** converts the chemically cleaned steel surface to a uniform phosphate coating. The "Granodine" coating being non-metallic is an ideal bond into which the paint finish is "keyed" or anchored;
4. **"DEOXYLYTE" final acidulated rinsing** conditions the Granodized steel surface for optimum paint life.



UNITED DRUMS fabricated from Standard Gauge Steel are available in all sizes, with special linings for a variety of products, and decorated with any desired design.

- **EXTRA PROTECTION** for the finish—a lasting bond between paint and steel.
- **EXTRA PROTECTION** for the steel container—an inert barrier against rust creepage.
- **EXTRA PROTECTION** for the contents—chemically clean interior surfaces.
- **EXTRA PROTECTION** for the customer—an assurance of cleanliness, durability, and fine appearance.

Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY

CHEMICALS ACP PROCESSES

General Offices: Ambler, Penna.

CHEMICALS ACP PROCESSES

Detroit, Michigan Niles, California Windsor, Ontario

NEW PRODUCTS

(Continued From Page 41)

this material in European industry and when the material is produced without the aid of plasticizers, the corrosion resistance is not reduced. Boltaron 6200, distributed by H. N. Hartwell and Sons, Inc. is the first such polyvinyl chloride to be used according to the company, an important clad metal producer.

●

A Caulking Compound that looks and feels like white tile yet can be squeezed from a tube to fill cracks and crevices has been produced by Sapolin Paints, Inc., 229 E. 42 St., New York City. The plastic rubber compound is said not to shrink, crumble or discolor with age and is waterproof.

●

Amercoat Corporation, 4809 Firestone Blvd., South Gate, Calif., has more than doubled the size of its research and laboratory facilities, with a new laboratory wing and executive office wing. This is the third major expansion for Amercoat in the past year, the company said.

●

Lunn Laminates, Inc., Huntington Station, N. Y., has announced the first package delivery truck body custom molded of reinforced plastics. The 19-part body was made by the contact press molding process. The body weighs only 650 lb., compared to 1700 lb. for an aluminum-steel type and is expected to reduce maintenance costs, purchase cost and cut gasoline consumption and increase tire life. One and two-ounce mats of Owens-Corning Fiberglas impregnated with polyester resins form the major parts of the body. Color will last as long as the body, without peeling or warping and the plastic is highly resistant to rusting, weathering and corrosion. The company expects to produce these bodies in quantity in the near future.

●

Polyethylene filter cloth which is free flowing, easily cleaned and slow to bind, with excellent chemical resistance has been produced by the National Filter Media Corp., New Haven, Conn. It is resistant to most acids, the common alkalis, some organic solvents and oxidizers, and most salts and oils, a company bulletin states. Samples and literature are available from the company.

●

Radioactive Tracers are finding new applications in chemical industry research according to the Alcoa News bulletin. The tracers are being used in lubricant evaluation, corrosion resistance studies, alloy development and many other projects. In the corrosion studies, a piece of metal is exposed briefly to a corroding solution containing a trace of radioactive material, then taken from the solution and checked by a Geiger counter. This allows an accurate count of the corrosion material pick-up.

●

A Rust Inhibiting paint formula, combining rust resistance with enamel-like appearance, has been announced by the Glidden Company, Cleveland, Ohio. Marketed as Nev-A-Rust, it contains a blend of alkyd resins with rust inhibitive pigments and linseed oil and is expected to be a valuable finish against the corrosive action of fumes and gases in and near industrial areas. It is also said to be unaffected by temperature extremes.

Napko Paint and Varnish Works, Houston will expand its activities in the Houston and Dallas areas. Gene Hanszen was appointed to represent the firm in Dallas and L. G. Sharpe was made sales engineer in the Houston area. Both Mr. Hanszen and Mr. Sharpe are members of NACE. Mr. Hanszen is a graduate of Rice Institute with a BS in chemical engineering received a Master's degree from Massachusetts Institute of Technology. He was associated for 12 years with Union Carbide and Carbon Co. where he worked on development of protective coatings and linings. He is a member of AIChE and the Society of Plastic Engineers. Mr. Sharpe is also a graduate of Rice Institute. For the past 8 years, he has been corrosion engineer for the Humble Pipe Line Co. He is the author of technical papers, and has been prominent in NACE activities both on a local and national scale, having served last year as chairman of the Houston Section and being the newly elected section trustee.

●

Atlas Mineral Products Company's Raymond B. Seymour has compiled recommendations about the applications of coatings, which, if followed, probably would be the means of many saved dollars. The questions of coating characteristics, surface preparation, application technique, resistance to various kinds of corrosives, abrasion and other agents is considered. A means of selecting a class of coatings is provided in a table of ratings. Dr. Seymour recommends close study of the intended service life before a coating is selected. Copies of the 24-page book can be obtained on request from Atlas Mineral Products Co., Mertztown, Pa.

●

Plastisols, "solutions" of polyvinyl chloride are being used as protective coverings for metal structures and industrial equipment by Arbonite Corporation, 900 N. Main St., Doylestown, Pa. These plastisols are said to have the ability to form effective barriers to chemical and electrolytic action, resist abrasion and to be good electrical insulators.

●

Bart Laboratories Co., Belleville, N. J., has developed a process for applying nickel directly to either raw or anodized aluminum, which is said to afford an erosion-resistant surface and materially strengthen the aluminum. The process eliminates the need for an intermediate bonding material.

●

Alcoa's new tapered sheet and plate rolling mill has begun producing sheet and plate up to 10 feet wide for the wing skins of military aircraft at Davenport, Iowa. Roll-tapered sheet previously was limited to much narrower widths.

●

The Caddy Taper-Lok quick connector featuring the Cadweld connection is being produced by Caddy Arc Welding Accessory Div., Erico Products, Inc., 2070 East 61 Place, Cleveland, Ohio.

●

Eleven Technical reference sheets covering the major stainless alloys are available from Cooper Alloy Foundry Co., Hillside, N. J. Resistance to major corrosive solutions, machinability, heat treatment, weldability, chemical composition and mechanical and physical properties are given for each alloy.

Benjamin Foster Co., 4635 West Girard Ave., Philadelphia, Pa., has issued a 20-page brochure on lagging adhesives, sealers, surface coatings, fire retardant mastics and vapor barriers. The Type 80 mastic has been tested and listed as approved by Underwriters' Laboratories for its high heat and fire resistance.

●

Weaver Engineering and Supply Co., Inc., has purchased an office and warehouse of 3500 square feet floor area at 718 W. Main St., Grand Prairie (Dallas) Texas in a move to expand its activities in the southwest.

●

Tubular Products Div. of the Babcock & Wilcox Co. has opened a new district sales office in Cincinnati at 2330 Victory Parkway. The company produces seamless and welded stainless, alloy and carbon steel tubing and pipe for pressure, mechanical and structural applications.

●

Resistoflex Corp., Belleville, N. J., opened a new office and assembly station in June at 4414 W. Jefferson St., Los Angeles to help provide initial quantities of the company's new lightweight, heat and corrosion resistant hose and hose assemblies to the West Coast aircraft industry.

●

E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. has issued a booklet on Teflon tetrafluoroethylene fiber.

●

Industrial Waste Treatment. Bulletin WC-116 published by Graver Water Conditioning Co., New York includes illustrations of the use of Graver equipment in solving problems such as process and cooling water shortages, contamination of streams and loss of heat and materials in waste fluids. Special attention is given to the petroleum, metal plating and paper industries. Copies are available from the company.

●

A 40-Page Bulletin on monoethanolamine, diethanolamine and triethanolamine which presents physical, toxicological and chemical properties, sales specifications, methods of analysis, uses and handling and storage information has been issued and is available on request from Jefferson Chemical Co., Inc., 260 Madison Ave., New York.

●

National Tube Division of United States Steel Corp., Gary, Ind., is installing equipment for the manufacture of plastic pipe. Extrusion of pipe is expected to begin in September, to include pipe between ½-inch and 6 inches in diameter.

●

Grieve-Hendry Co. Inc., manufacturers of laboratory and industrial ovens, is moving its factory to larger space at 1401-17 W. Carroll Ave., Chicago 7, Ill.

●

Devilbiss Co., 300 Phillips Ave., Toledo, Ohio have developed an economical method for surface preparation of glass fiber reinforced plastic automobile bodies which is said to open the way to painting the bodies in the conventional manner, using dark, medium or light colors.

●

A Portable Arc Welder weighing 65 pounds and operating on either 110 or 220 volt AC 60 cycles with a rated output of 200 amperes, is manufactured by Brennen, Bucci and Weber, Inc., and is available from Kasson Die & Motor Corp., 32-14 Northern Boulevard, Long Island City, N. Y.

PERSONALS

F. M. A. Noblet was promoted from assistant treasurer to treasurer of both companies. He succeeded William J. Hutchinson, who also will continue to serve on the executive committee.

Ralph D. Parker was elected general manager of Canadian operations, **Walter C. Kerrigan** was made assistant to the president and **Herbert G. Fales** became assistant to the chairman of the International Nickel Co., of Canada.

L. R. Larson was elected general sales manager and a vice president of the company. New assistants to the vice president of the Canadian company are **Richard A. Cabell,** assistant secretary and **Paul Queneau,** metallurgical engineer, who will serve with **Ralph H. Waddington** and **A. Godfrey,** who were re-elected to these positions. Mr. Queneau will also serve as assistant vice president of the United States company along with Mr. Cabell, who was re-elected to the post.

●

A. B. Drastrup, executive vice president of A. M. Byers Co., Pittsburgh, was elected a member of the board of directors of the company April 26. He fills a vacancy on the board created when J. W. Marriman resigned from the company after being with it for 38 years.

●

Eugene W. Cornwell, formerly chief plant engineer of the Fredericksburg, Va., cellophane plant of the Sylvania Division of American Viscose Corporation has been promoted to advisory engineer of the division Sept. 1. **Edward L. Wooley** will succeed Mr. Cornwell as plant engineer. He is now assistant plant engineer of the corporation's acetate plant at Meadville, Pa.

●

Alfred H. Pope, formerly a member of the Pennsylvania Salt Manufacturing Company's Technical Department staff, has been named product supervisor for Pennsalt's metal cleaners. He will be replaced by **William T. West.**

●

New chief appraisal engineer of Ebasco Services Incorporated is **John J. Reilly,** who succeeds **W. M. Black,** now a consulting appraisal engineer for the company. Mr. Reilly will be responsible for the supervision and preparation of engineering valuations and depreciation studies.

●

American Foundrymen's Society awarded the Wm. H. McFadden Gold Medal to **Walter E. Sicha,** chief of the Cleveland Research Division of Aluminum Company of America, at the society's 58th Annual Convention in Cleveland, Ohio. He was cited for "extensive and valuable work on light metal casting alloys and for outstanding contributions to the society."

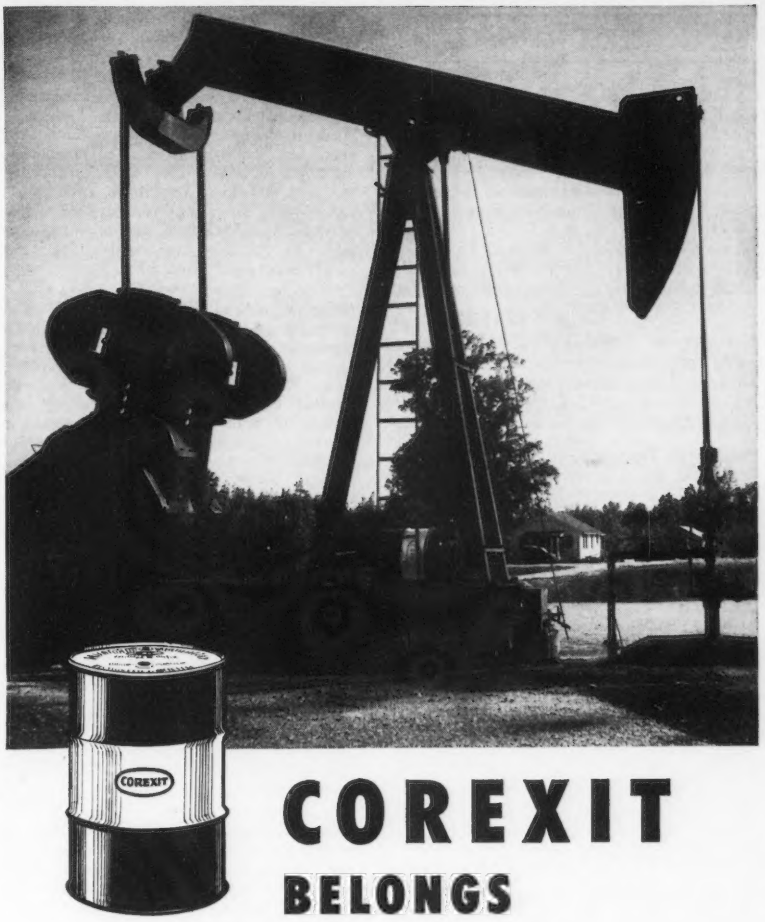
●

Hagan Corporation's president, **David J. Erikson,** has retired because of ill health but will continue to serve the company as consultant. He has been succeeded by **W. W. Hopwood,** son of the founder of the company.

●

William L. Monroe has been appointed Assistant to the sales manager of the Dresser Manufacturing Division, Bradford, Pa.

(Continued on Page 44)



COREXIT
BELONGS
IN THIS PICTURE

. . . because it will save you money.

Tests show that daily use of COREXIT — the corrosion inhibitor for sour crude, gas condensate and other oil wells — can save you up to $800.00 per well per year. COREXIT'S patented compound protects against the severe corrosive conditions in wells by building up a protective coating on tubing and sucker rods.

Protect your sucker rods and tubing from corrosion and hydrogen embrittlement. Call the nearest Humble Wholesale Agent (in Texas) for on-the-lease delivery of COREXIT, or write:

Sales Technical Service
Humble Oil & Refining Co.
P. O. Box 2180
Houston, Texas

HUMBLE

HUMBLE OIL & REFINING CO.

PERSONALS

(Continued From Page 43)

Prof. Charles O. Gunther has become a research consultant for the L. B. Foster Co. He formerly was head of the Stevens Institute of Technology mathematics department and is a leading expert in ballistics and engineering.

•

Alcoa's new works manager for its Richmond, Ind., works is **J. M. Hileman,** fabricating division staff assistant in the Pittsburgh Office.

•

Robert M. Burford has been named sales supervisor of the newly created Buffalo district for the Metal Processing Department of the Pennsylvania Salt Manufacturing Company.

•

Selden E. Doughty, former chief metallurgist at the Union Mill of the Carpenter Steel Company, has been appointed production manager of the company's Alloy Tube Division. He will supervise the division's production, engineering, scheduling and personnel.

•

Acheson Colloids Co., Port Huron, Mich., has announced the appointment of **Richard G. Hartnett** as service engineer. He will work out of the company's Cleveland office and serve the state of Ohio.

•

Myron A. Tracy, former deputy for material programs in the office of the Assistant Secretary for Materiel of the Air Force, Washington, D. C., joined the Garrett Corp., Los Angeles, on May 10, as a member of the staff of J. C. Garrett, president.

•

Carpenter Steel Co., Reading, Pa., has appointed four new Midwest district and branch managers. **William J. Ervin, Sr.,** has been promoted to district manager of the Indianapolis territory and the Southwest with headquarters in Indianapolis. **Paul Holtz** is assistant Chicago district manager and also has responsibility for sales and service in the St. Louis area. He will remain in Chicago. **William J. Stephens** has been promoted from assistant manager to branch manager of the St. Louis Mill Branch Warehouse. **William C. Kunkelman** has been named Southeastern manager in charge of sales and service in the Atlanta, Cincinnati and Dayton territories with headquarters in Cincinnati. **K. L. Crickman,** regional manager, after 26 years of service with the company, is retiring June 30.

•

Atlas Mineral Products Co. has announced several personnel changes. **Kenneth T. Snyder,** now Western regional sales manager; **Eugene Kirkpatrick, Eastern** regional sales manager; **Walter Pascoe,** assistant research laboratory director; **Willis Thomas,** research chemist; **George Baumgartner,** in charge of the customer service laboratory; **Erik Van Anglen,** member of the sales management group, Thermoplastic Structures Division; **David Reinert,** research engineer; **Ernest Derr,** member of the technical service dept., Houston; **James Baird,** member of the advertising group; **Richard South,** district sales manager of the Detroit area and **Frank Bearchner,** sales engineer for the Cincinnati district.

•

A. David Lewis, Jr., is now creosote oil sales representative for Reilly Tar & Chemical Corp.'s Southeastern territory and will have his headquarters at Reilly Tar & Chemical Corp., 4900 Central Ave., Chattanooga, Tenn.

•

John S. Coppage has joined the Permutit Co., New York, N. Y., as manager of sales of the chemical service division. He will be responsible for directing field salesmen and engineers in the application and sale of chemical service division products and services.

•

Frank L. LaQue has been elected vice-president of the International Nickel Co., Inc., and manager of its Development and Research Division. He succeeds in both positions **Thomas H. Wickenden,** who will continue to serve the company as consultant. **O. J. B. Fraser** and **Donald J. Reese** will be assistant managers of the division. Mr. LaQue, a past president of NACE, was instrumental in organizing the Inter Society Corrosion Committee and has received numerous honors for his achievements in corrosion science and technology.

•

Woodrow W. Carpenter will investigate the problems encountered in the rapidly expanding applications of ceramic finishes to industrial use in his new position as director of research for Barrows Porcelain Enamel Co., Cincinnati, Ohio. Carpenter was born in West Union, Ill. and graduated from the University of Illinois with a BS in ceramic engineering. He was employed by Ingram-Richardson Mfg. Co., Frankfort, Ind., in a supervisory research capacity before joining Barrows.

•

George H. Reed has been made manager of the combined Chemical Equipment and Plastic Division of the American Hard Rubber Co. He graduated from the Pratt Institute of Technology as a chemical engineer and joined American Hard Rubber Co., in 1934.

•

Changes in the executive staff of International Nickel Co., Inc., 67 Wall St., New York, N. Y. made at the annual organization meeting of the board of directors are: **Henry S. Wingate** was elected President of the International Nickel Co., of Canada and to membership on the executive committee of the Company as well as the presidency of the United States subsidiary, International Nickel Company, Inc. He succeeds Dr. Paul D. Merica who will continue as director of the executive committee.

•

William C. (Bill) Enright has been appointed sales manager of Automotive Rubber Co., Inc., Detroit, Mich.

•

President of the Brooklyn Chamber of Commerce is **Selden T. Williams,** vice president of Scovill Manufacturing Company and president and general manager of its A. Schrader's Son Division, headquarters in Brooklyn.

•

Hagan Corp., Pittsburgh, has named **M. J. Boho** general manager of the corporation and its subsidiaries, including Hall Laboratories, Inc., Calgon, Inc. and the Buromin Company.

•

Philip Jones, formerly manager of organization development of R. M. Hollingshead Corp., has been elected secretary of the corporation and assistant to the president.

•

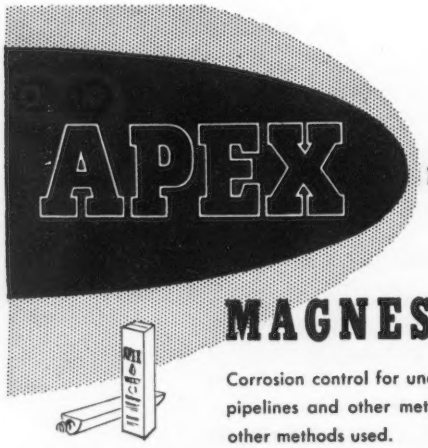
Frank W. Nelson has been promoted from assistant manager of Garrett Supply Co., Los Angeles to manager.

•

Keith E. Demorest, a specialist in layout and design of water treating equipment and Conrad E. Lawlor, industrial sales engineer recently joined the staff of General Filter Co., Ames, Iowa.

•

Ralph F. Burns has been appointed Manager Metal Sales, Western District, of the New Jersey Zinc Sales Co., Chicago, Ill.



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Corrosion Abstracts

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5. PREVENTIVE MEASURES

5.4 Non-Metallic Coatings and Paints

5.4.2

The Galvanic Corrosion Theory for Adherence of Porcelain-Enamel Ground Coats to Steel. DWIGHT G. MOORE, J. W. PITTS, J. C. RICHMOND, AND W. N. HARRISON. National Bureau of Standards, June, 1953. 19 pp.

The galvanic corrosion theory of adherence between ground-coat enamels and steel was investigated. The theory, which is based on mechanical anchoring of the enamel into pits formed by galvanic attack of the enamel on the steel, was first examined from the standpoint of data on adherence obtained in earlier studies. Also, several experiments were performed which demonstrated that galvanic corrosion could occur during the short firing times encountered in enamel processing. However, inconsistencies were observed in the data which indicated that the mechanism of galvanic attack followed by mechanical anchoring was not the only important factor affecting bond strength. Diagrams, graphs, illustrations and eleven references.—NSA. 6373

5.4.2, 2.3.7

Porcelain Enamels and Ceramic Coatings, Prime Inhibitors of Metal Corrosion. DWIGHT G. BENNETT. *Corrosion*, **10**, No. 1, 13-20 (1954) Jan.

Some of the pertinent background of present day developments in protecting metal from corrosion by means of ceramic coatings is reviewed. Test methods are presented and the evaluation of selected tests discussed. Some examples of coating effectiveness and areas in which coatings could be used to advantage are presented. 6481

5.4.3, 7.3, 8.3.1

Porcelain Cylinder Liner Protects Pump from Corrosive Chemicals. *Product Eng.*, 24, No. 5, 166-167 (1953) May.

In agricultural spray equipment, the steel pump cylinders are lined with porcelain for protection against corrosive chemicals like lime, calcium chloride and sulfide compounds. The lining, applied in three coats provides a uniform, hard, polished surface.—INCO. 6454

5.4.5

Corrosion Resistant Metal Coating. *Sheet Metal Worker*, **44**, No. 7 86 (1953) April.

Recent developed addition to the "Vinsynite" group of corrosion resistant metal coatings, is designated as Vinsynite FS-3. It is offered as a stable type treatment formulated especially for roller coating on ferrous metals. This is intended for use under top coats, but will itself protect surfaces for short periods of time.—INCO. 6598

5.4.5, 7.3, 7.2, 7.4.2

Pad With Neoprene to Save Critical Parts From Corrosion and Wear. *Power*, **97**, No. 1, 103-105 (1953) Jan.

Bill Sesher of Synco Corp. of Emmaus, Pa. has perfected coating technique so failures are uncommon. Parts to be coated are first sandblasted. Primer is then applied. After primer, as many as 40 coats of neoprene are brushed or sprayed on. Coated part is then baked for thorough curing. Photographs of condenser tubes, pump impeller and a centrifugal pump before and after coating, 70% nickel-alloy pump impeller and steel valves are included.—INCO. 6458

5.4.5, 5.3.2

Vinylite Resin Coating Improves Corrosion Resistance of Galvanized Iron. *Products Finishing*, **17**, No. 6, 68-69 (1953) Mar.

Tough, flexible coatings based on Vinylite plastic resins resist moisture, abrasion, aging, weathering besides corrosive acids, alkalies and most other chemicals. Exposed for 1204 hr continuously in a salt spray fog cabinet, a panel of corrugated, galvanized iron, unprepared but treated with a primer and top coat based on Vinylite resins, showed no signs of corrosive breakdown throughout the test. An uncoated panel lasted only 672 hr. under the same severe conditions before the galvanizing completely deteriorated. Photograph.—INCO. 6453

5.4.5

Phenolic Resin Coatings for Corrosion Resistance. *Machinery*, **59**, No. 7, 190-191 (1953) Mar.

Ric-wiL Plastic Coating & Mfg. Corp. introduced 2 new phenolic resin coatings, Ricwilite 1060 which hardens to form a chemically inert, insoluble corrosion resistant coating when baked at 350-400°F. and Ricwilite 7100 which is of the cold-setting type, being cured at room temperature (60-80°F) by adding a catalyst prior to application. These resins form a film which is resistant to corrosive acids and alkalis, salt water, rust and weathering. Applications.—INCO. 6378

5.4.5, 4.6.11

Rutgers U. and Navy Team Up to Speed Corrosion Research. *Am. Paint J.*, **37**, No. 44, 9-10 (1953) July 7.

The Navy and Rutgers are working together to investigate the properties, structure and function of a new anti-corrosion agent consisting of phosphoric acid, a resin and an inhibitive pigment. The corrosion inhibitor has excellent adhesion and resistance to salt water. The work at Rutgers is being directed by E. R. Allen. 6367

6. MATERIALS OF CONSTRUCTION

6.4 Non-Ferrous Metals and Alloys—Light

6.4.4, 5.3.2, 3.5.8

Corrosion Tests on Bare and Clad Magnesium Sheet. B. J. NELSON. *Modern Metals*, **9**, No. 1, 63-65 (1953) Feb.

Following extensive corrosion and stress corrosion tests, carried out on AM3S, AMC52S and AMC54S sheet and clad versions of the last two alloys, it was concluded that composites consisting of ingots of AMC52S or AMC54S and plate of AM3S can be successfully bonded and rolled. Tensile strength of "clad" sheet can be computed with fair accuracy if each portion of the composite sheet contributes its nominal share. AMC52S and AMC54S have better resistance to ordinary corrosion than clad alloys of the same core composition with AM3S coatings. As long as a portion of the cladding remains, the core alloy is protected against general corrosion. Resistance to atmospheric corrosion of all the alloys as well as AM3S is within the same order of magnitude. Although AM3S coatings will not prevent stress corrosion cracking 100 percent, they do improve the resistance to this type of failure. Clad AMC54S is definitely more resistant to stress corrosion cracking than bare AMC54S. Clad AMC52S is more resistant to stress corrosion cracking than bare AMC52S but as failures for these products were confined to the simple beam test, the advantage afforded by the AM3S coating is not as marked as AMC54S. AMC52S and clad AMC52S sheet are more resistant to stress corrosion cracking than AMC54S and clad AMC54S. AM3S sheet is not susceptible to stress corrosion cracking.—ALL. 6350

6.4.4, 3.7.2

Preparation of High-Purity Magnesium and a Study of the Effect of Non-Metallic and Alkali-Metal Impurities on the Corrosion Characteristics of Pure Magnesium. (Biennial Report). U. S. Atomic Energy Commission Publ., 1952, (COO-85), 27pp.

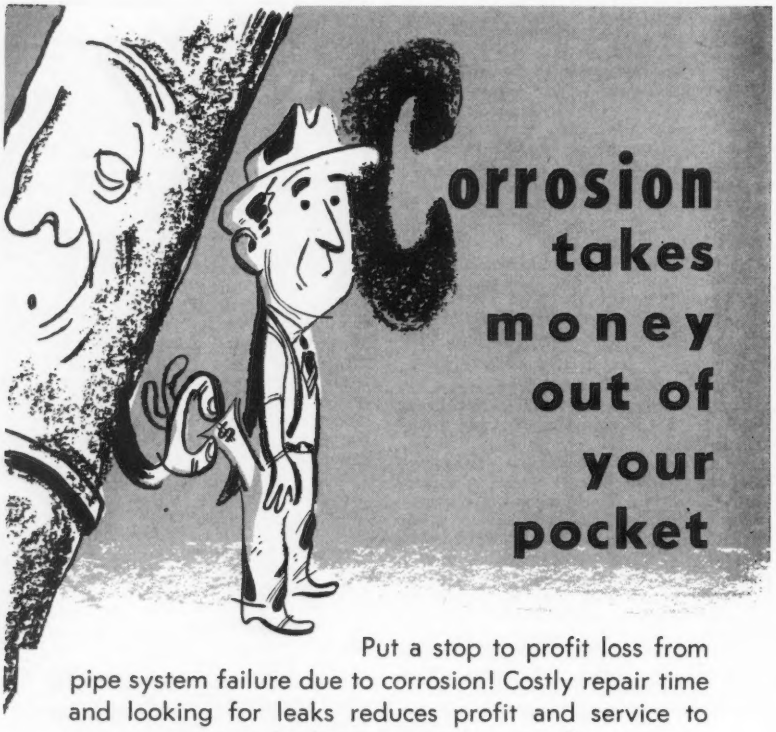
Extensive corrosion studies were made by the Dow Chemical Co. on pure binary magnesium alloys containing non-metallic elements and alkali and alkaline-earth metals. Sodium and calcium, and possibly carbon, were the only elements which were detrimental to the corrosion properties; lithium, barium, strontium, potassium, silicon, chlorine, nitrogen, oxygen, and phosphorus had no measurable effect provided that the magnesium was pure, although there were indications that some of these elements were very detrimental if iron was present. Phosphorus increased both the extent of the solid solution of iron in magnesium and the solution potential of magnesium-

iron alloys. A re-evaluation of the corrosion properties of pure magnesium-iron alloys resulted in a much lower tolerance limit for iron (approximately 65 p.p.m.) than that previously accepted, and the maximum corrosion rate was obtained at approximately 150 p.p.m. iron. With increase in the iron content, the finely dispersed particles increased in number up to approximately 150 p.p.m. iron, at which composition coalescence of the particles occurred. Thus the corrosion rate obtained corresponded closely to the surface area of the second phase, which is in agreement with the cathodic nature of the particles. The corrosion rate of magnesium alloys containing iron was found to be markedly affected by the rate of solidification and cooling and by subsequent heat-treatment. Solution-treatment for 16 hr. at 1100°F. (595°C.) of magnesium-iron alloys containing approximately 150 p.p.m. iron resulted in a twenty-fold decrease in the corrosion rate, owing to changes in the dispersion of the second phase. Slowly cooled alloys containing 450 p.p.m. iron had higher corrosion rates than those cooled rapidly. Purification of magnesium by vacuum sublimation resulted in a product with greatly improved resistance to corrosion.—MA. 6079

6.4.4, 5.3.2

Long-Time Corrosion Tests On Bare and Clad Magnesium Sheet. B. J. NELSON. Nov., 1952, 10 pp. Published by Magnesium Association (U.S.A.), 122 East 42nd Street, New York 17, N. Y., U. S. A.

Investigation of 0.064 inch thick AMC52S (magnesium—3% aluminum—1% zinc—0.5% manganese) or AMC54S (magnesium—5% aluminum—1% zinc—0.2% manganese) having a coating of AM3S (magnesium — 1.5% manganese) on both sides; also sheets of the separate alloys mentioned. Metallographic examination, mechanical properties, potential measurements (degree to which coating is anodic), corrosion and stress corrosion tests in industrial and sea coast atmospheres, and stress corrosion tests in sodium chloride-potassium chromate solution.—BNF. 5927



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Houston, Texas

174a

6.6 Non-Metallic Materials

6.6.6, 6.5, 3.5.9

Behavior of Refractory Oxides in Contact with Metals at High Temperatures. G. ECONOMOS. *Ind. and Eng. Chem.*, 45, No. 2, 458-459 (1953) Feb.

Study of the behavior of refractory oxides in contact with metals at elevated temperatures. Al_2O_3, MgO, BeO, ZrO_2, TiO_2, ThO_2 were the refractory oxides used and titanium, beryllium, silicon, niobium, nickel, molybdenum and zirconium were the metals used. Nickel and molybdenum were the only metals of those tested which were stable in contact with the oxides at all temperatures. Titanium and zirconium reactivity increased with the temperature, probably because of an oxygen exchange mechanism. Results are summarized in chart form. Illustration, 14 references.—INCO. 6644

6.6.6, 4.7, 8.4.5, 3.5.9, 6.7.2

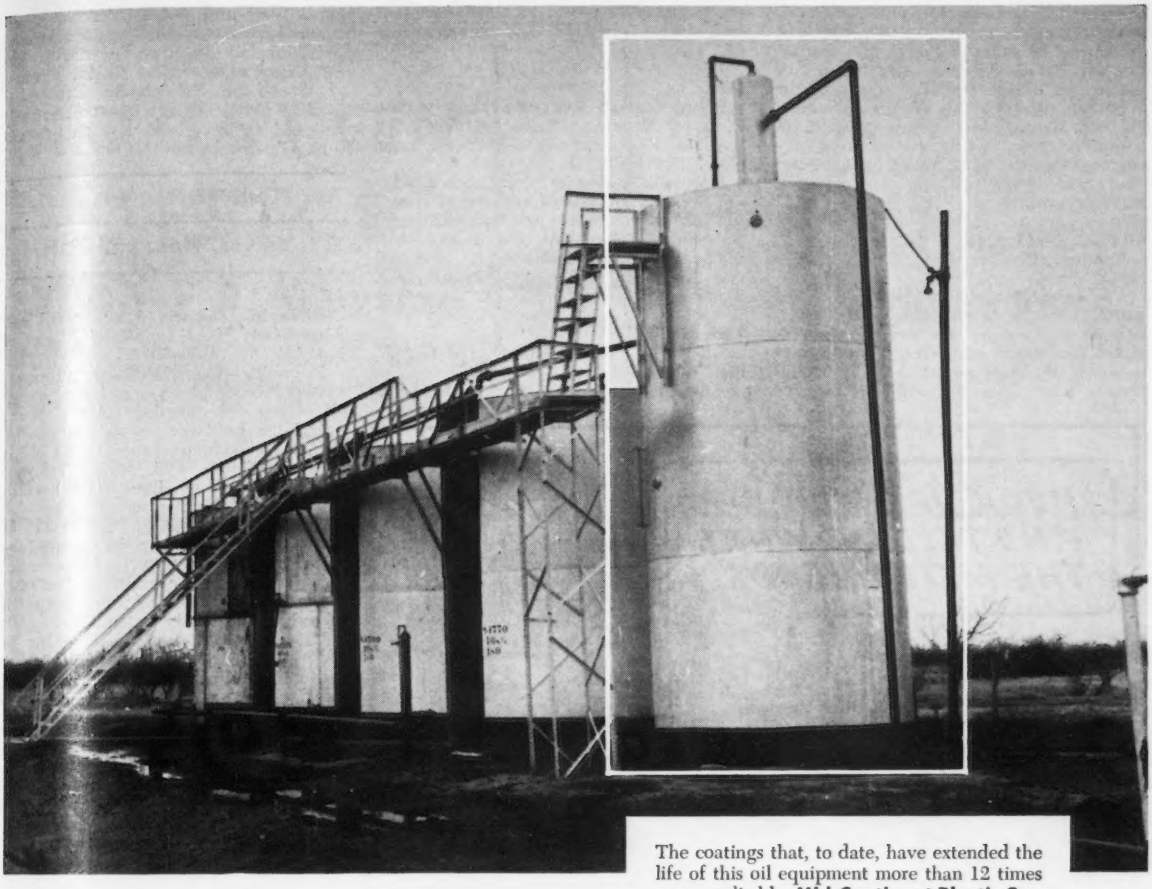
Ceramic Materials for Reactors. Papers before Am. Ceramic Soc., Refractories Div., 55th Ann. Mtg., N. Y., April 26-30, 1953. *Nucleonics*, 11, No. 7, 20-21 (1953) July.

Papers include: Nuclear Power Applications, J. M. Warde (Oak Ridge National Lab.); Properties of Hafnium Oxide, C. E. Curtis (Oak Ridge National Lab.); Resistance of Metallic and Ceramic Refractories to Attack by Liquid Metals, E. L. Reed (No. American Aviation, Inc.); Cemented Chromium Carbide, E. W. Engle and G. W. Lucas (Carboloy General Electric Co.); Pressure-Sintered Dense Silicon Carbide, R. A. Aliegro and J. R. Tinkelpaugh (Alfred Univ.); High-Temperature Strength of Oxide-Base and Carbide Base Cements and Related Physical Properties, E. T. Montgomery (Ohio State Univ.). The most widely used composition of cemented chromium carbide, No. 608, consists of 83% chromium carbide, 2% tungsten carbide and 15% nickel binder. Iron, nickel, chromium, molybdenum, cobalt, iron-silver, iron-boron, nickel-boron and chromium-molybdenum were among the metals tried as binders for a silicon carbide cement. The first four were selected as being best for reaction between silicon carbide and the metal. Results of corrosion tests in sodium, bismuth and tin in liquid and vapor states are tabulated.—INCO. 6385

6.6.8, 1.3, 1.5

Basic Criteria for Evaluating Some Plastic Materials of Construction. RAYMOND B. SEYMOUR. *Corrosion*, 10, No. 1, 37-47 (1954) Jan.

Fundamental information about plastic materials as to their generic characteristics is followed by a discussion of the atomic construction of the principal classes of plastics. Differences in



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the chemical resistance of polar and non-polar materials are explained. Physical properties of some of the principal plastics are listed. After a brief history of the origin of the so-called synthetic or artificial plastics, 30 of the principal plastic materials are considered with respect to their atomic composition, resistance to corrosives, techniques for use and some of the principal uses of each as structural materials. 6477

6.6.8, 7.2, 4.6.11, 3.5.3

Testing. *Product Eng.*, **24,** No. 7, 9 (1953) July.

Preliminary tests show that Nylon has superior erosion and corrosion resistance when used as trim material in seawater line valves of both globe and gate types. Navy tests report that the Nylon inserts when subjected to high-velocity sea water were found to be in excellent condition after 18 months service.—INCO. 6504

6.6.8

High Impact Styrene Copolymers. R. B. Seymour and R. H. Steiner. Atlas Mineral Products Co. *Chem. Eng.*, **60,** No. 1, 254 + (1953) Jan.

Corrosion resistance of these newly-developed materials of construction to a number of corrosives with physical and mechanical properties, forms available, applications, machinability and chemical resistance properties are discussed. Photograph, charts.—INCO. 6531

6.6.8, 7.2, 7.5.5

All-Plastic Tank Battery. *Oil Gas J.*, **51,** No. 50, 161 (1953) April 20.

All-plastic tank battery made from glass fiber and polyester resin is used on a pilot-water-flooding operation of Superior Oil Co. near Owensville, Ind., for handling corrosive fluids. Piping is of Cres-Line BR plastic. Problem of joining plastic pipe with steel valves is believed to be solved with this installation. Illustrations.—INCO. 6376

7. EQUIPMENT

7.2 Valves, Pipes and Meters

7.2, 6.4.2, 8.4.3

Reynolds Reports Another Oil Field Aluminium Use. *Am. Metal Market*, 60, No. 129, 5 (1953) July 4.

Reynolds Metals Company reports that refineries, gas processing plants and all types of treating plants in the petroleum industry are shifting over to the use of aluminum instrument lines because of the 40% saving compared to cost of copper lines. The lines are small size tubing ranging from ¼ to ⅝ in., some 15 to 20 miles of which are used in each refinery for transmitting liquid and gas pressures from various points in the processing equipment to centralized control and instrument panels. Aluminum not only has good resistance to normal exposure, but also has the ability to withstand the hydrogen sulfide present in the atmosphere, around refineries and treating plants, and thus the lines require no protective coating.—ALL. 6227

7.2, 6.4.2, 8.9.3

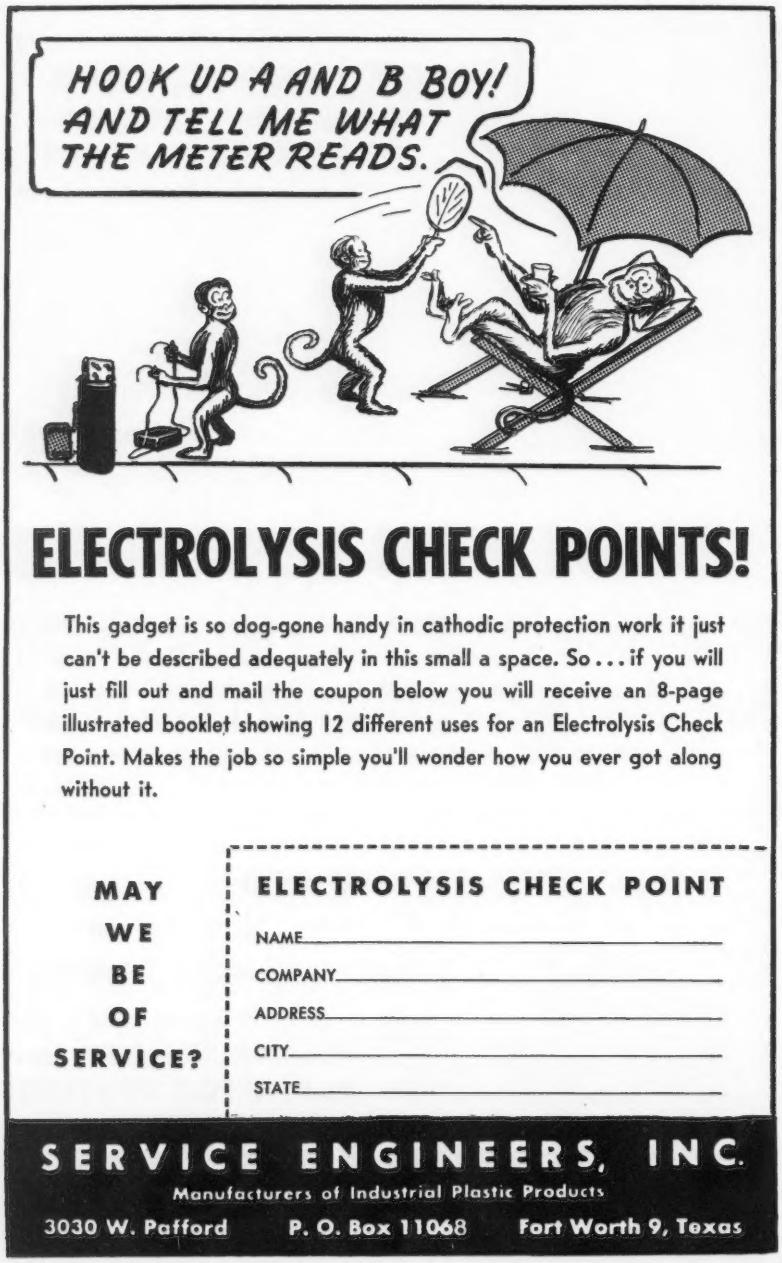
Aluminium Piping Shown to be Time and Money Saver in Gas, Oil Fields. *Am. Metal Market.* **60,** No. 100, 9, 10 (1953) May 26.

Reynolds Metals Company have found that when installing pipelines through swamps, over mountain ranges and in lake, ocean and river crossings, aluminum saves money. Recently two aluminum pipelines were installed in the Permian Basin to be used for gathering sour gas, where its light weight allowed use of a fast automatic welding system by which complete 40 ft. lengths of 6 in. pipe are lined up, welded and lowered at the rate of one every 3 minutes. River crossing installations have been made including a 10¼ in. diameter, 3/16 in. wall gathering line carrying sweet natural gas at pressures up to 250 lb./sq./in. across Little Colorado River, Oklahoma, which uses eleven 30 ft. sections of extruded aluminum pipe with ends beveled 30° for welding. Total span length is 318 ft., and it was welded on a wooden scaffold on the first pier and pushed ahead 30 ft. onto a cable suspension system as each well was completed. A single 1¼ in. steel cable supports the entire system. Alabama-Tennessee Natural Gas Company installed a 1.8 mile length of underground gas line, using 8½ in. outside diameter, ¼ in. wall, 63 S-T6 extruded aluminum pipe, which was furnished in 40 ft. lengths.—ALL. 6239

7.2, 7.1, 7.10

Spring Failures by Corrosion. F. P. Zimmerli. *Metal Progress*, 62, 84-88 (1952) July.

Corrosion is a more common cause of spring breakage than is usually appreciated by the user. It is caused in most valve springs by condensation of the products of combustion. A little pit is formed, or there is hydrogen embrittlement from the oxidation of the



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177a

steel. It is revealing to know how fast this breakage may be. Perfect springs have been made to fail in three to six hours in an overcooled motor, or in one that was started and stopped before it could run long enough to scavenge the crankcase. The usual methods to overcome this trouble are a. to protect the surface of the springs from corrosion; b. to use stainless steel for the springs; or c. remove the cause of corrosion. In any event, failure by corrosion is difficult to detect because the little pit or fleck of rust is not easily seen. An unbelievably small amount of corrosion on a spring in active use, as a valve spring, can do the damage, leaving a break that is somewhat like a regular fatigue fracture. When corrosion is likely to occur, every effort should be made to stop it, as failure is certain in highly stressed springs in rapid use. Under static conditions it is not necessarily so. Springs have rusted out as much as three-quarters of the wire diameter (with, of course, gradual load loss) without actually breaking as long as they were not called upon to move. Vibrating springs which depend on shot-peening to supply them with the additional endurance necessary will fail if this peening is improperly done or the stressed surface removed by corrosion. The fracture will be that of a typical fatigue failure.—TIME. 5864

7.2, 8.1.4

Coatings for Steel Water Pipe. WALTER H. CATES. *J. Am. Water Works Assoc.*, **45**, 103-112 (1953) Feb.

Assemblies and summarizes present knowledge on effectiveness and approximate cost of available coating materials. Discussion is confined to steel water pipe 4 in. or more in diameter. Tables. 15 references.—BTR. 6275

7.2, 8.4.3, 1.3, 1.2.2

Corrosion of Casing in Oil and Gas Wells. JACK L. BATTLE. *Corrosion*, **9**, No. 9, 313-320 (1953) Sept.

In January, 1952, there were 482,260 producing oil and gas wells in the continental United States, having an average depth of 3888 feet. Assuming 7-inch OD 29-pound casing, these wells were equipped with approximately 27 million tons of steel in the oil string, having a present-day replacement cost of about $5,000,000,000. These wells should produce crude oil reserves estimated at 26 billion barrels plus some 4.5 billion barrels of natural gas liquids. A limited pooling of companies participating in NACE Committee TP-1H activities indicates that in fields in which only 45,830, or less than 10% of these wells are located, repair of casing due to corrosion failure is costing these companies in excess of $2,000,000 annually at the present time. This is exclusive of loss of production due to down-time, premature abandonment of isolated wells and factors of a less tangible nature. Obviously, the total loss to industry is great and can only be estimated. This paper discusses the various causes of such corrosion failures, the presently used methods of repair and preventive measures currently being practiced. The results of a survey of one operator's experience over a 10-year period is drawn upon in some detail. 6071

7.2

Brazed, Welded Tubing Coated for Corrosion Protection. HERBERT CHASE. *Iron Age*, **171**, No. 5, 118-119 (1953) January 29.

Brazed and welded ferrous tubing, fortified with copper, tin, or lead coatings for corrosion protection is rapidly produced on a continuous basis at Rochester Products Division of General Motors Corp., Rochester, N. Y. Starting as ribbons of steel, tubing is formed, brazed or welded, both dipped or electric plated, tested, and coiled or cut to length. Photographs.—BTR. 6264

7.2, 5.2.2, 5.4.10

Fighting Underground Corrosion at the New Fairless Works; How Piping and Other Services are Protected. WILLIAM E. COLEMAN AND HAROLD G. FROSTICK. U. S. Steel Corp., New York. *Heating, Piping, Air Conditoning*, **25**, No. 4, 85-87 (1953) April.

The four features of the new underground system at the Fairless Works complement one other another in combating underground corrosion. 1. Elimination of bare copper underground reduces galvanic corrosion. Steel rather than copper is used for electrical grounding. The electrical circuits between the steel rods and the steel structures are made with copper cables, but the cables are neoprene-covered to prevent contact with the earth. Rod connections are taped with neoprene, and connections to building framework are above ground. Consequently, for all practical purposes there is no bare copper in the earth, and the development of galvanic cells between copper and other necessarily exposed metals is avoided. 2. Magnesium anodes protect the steel ground rods and serve to partly protect all underground piping, lead cables, and foundations. Elimination of the copper in the earth makes it economically possible for the magnesium to protect the steel. The magnesium anodes are buried near the steel ground rods and are electrically connected to them above the ground. 3. Insulating coverings on pipes and cables protect their metallic surfaces and reduce the requirement for cathodic protection. A coating of coal-tar enamel and then a wrapping of coal-tar-saturated asbestos felt are used on pipe. On lead-sheathed power and communication cables, a neoprene jacket is used as a barrier between the metal and the moist earth. Under these conditions current can leave the covered metal only at designated drainage points or at incidental holes and breaks in the protective cover. Even these small breaks may receive some protection from the magnesium anodes. 4. Clearly marked, maintainable ground beds, consisting of steel rods and magnesium anodes are carefully placed for the protection of electrical equipment and personnel. They have been designed as independent units that can be used for test points on earth-current studies. The steel rods and magnesium anodes are wired in separate circuits, which permit measurements of stray- and cathodic-protection currents. —PDA. 6300

7.5 Containers

7.5.2, 8.3.3, 5.8.2

Aluminium Versus Tinned-Steel Milk Cans—A Comparative Study. GLENN R. WATSON, L. R. BRYANT and W. H. SPROULE. *Sci. Agr.*, **32**, 337-350 (1952) June.

A comparative study of aluminum and tinned-steel milk cans is presented. These investigations included the determination of the effect of milk and cream on aluminum and its alloys, the effect of storage of milk products in aluminum and tinned-steel cans, the effect of cleaning and sterilizing solutions on aluminum and tinned-steel, the numbers of bacteria remaining in milk cans after commercial cleaning and the effect of service on aluminum and tinned-steel cans. A series of corrosion tests showed that aluminum and its alloys are not appreciably corroded by milk and cream. Evidence is presented which indicates that a corrosion-resistant film is built up on aluminum. The flavor and quality of milk products are not affected by storage in aluminum and tinned-steel cans which have been well tinned. Storage of milk products in partially rusty cans results in deterioration of quality and flavor. Corrosion tests revealed that most alkaline cleaning compounds which are corrosive to aluminum are also corrosive to tinned steel. Inhibition of corrosion by alkaline compounds (except sodium hydroxide) may be accomplished by the addition of sodium metasilicate. Aluminum is more resistant to corrosion by acid can washing solutions than is tinned-steel. Chlorine solution, at a strength of 100 p.p.m. available chlorine, were found to be relatively non-corrosive to aluminum unless they were stabilized by trisodium phosphate. Iron (as in rusty cans) is rapidly attacked by chlorine solutions. Bacteriological examination of 1400 milk cans using a controlled rinse technique revealed that aluminum cans contained relatively fewer numbers of bacteria, after the completion of commercial wash-

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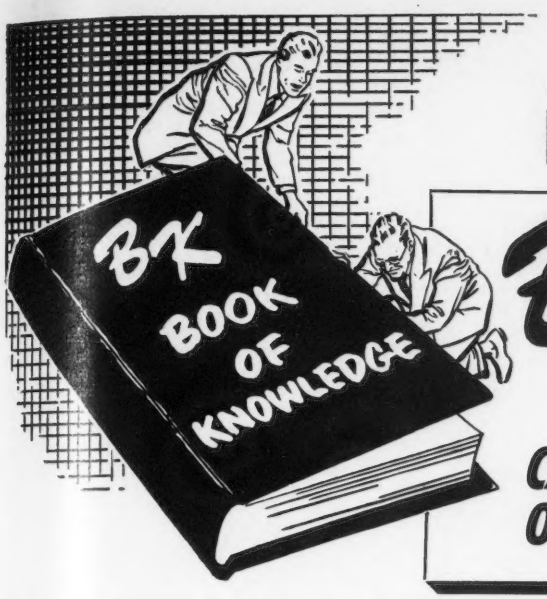

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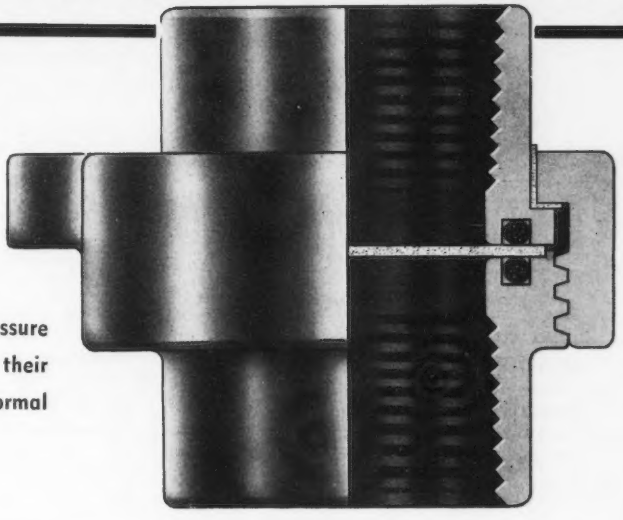

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ing procedures, than did tinned-steel cans. Evidence is presented which indicates that aluminum cans will have a longer service life than tinned-steel cans. —ALL. 5860

7.5.5, 5.2.3, 2.3.5

Cathodic Protection Applied to Tank Bottoms. Scott P. Ewing and J. S. Hutchison. *Corrosion*, **9**, No. 7, 221-231 (1953) July.

Laboratory studies are presented in which a method was devised for determining cathodic current requirements for the protection of storage tank bottoms. This method involves the determination of current distribution efficiencies on tank bottoms from four terminal resistivity measurements. For the purpose of this report the efficiency of current distribution may be defined as the ratio of the current density at the tank bottom center to the average current density. This method offers the corrosion engineer a possible method for estimating the resistance and effectiveness of various tank bottom coatings and pads. Its use offers possibilities for determining the current required to protect either a coated or uncoated tank bottom.

Initial tests of the method were made on three storage tanks near Houston, Texas. Since measurements were made on empty storage tanks in which the release of load had produced warping of the bottom, there was some inconsistency between test data and calculated values. This investigation also revealed that current-potential curves were not reliable in fixing adequate cathodic current values for tank bottom protection. Due to limited number of field tests made, this method should not be considered completely proved at this time. 6113

8. INDUSTRIES

8.9 Group 9

8.9.5, 1.2.2, 5.1, 4.4.6

Symposium on Control of Internal Corrosion of Tankers. Part 1. The Nature of Corrosion and Its Control. William B. Jupp. *Corrosion*, **9**, No. 11, 388-394 (1953) Nov.; *Trans. Soc. Naval Architects and Marine Engrs.*, **60**, 382-441 (1952).

Tanker vessels operated in salt water have developed serious bulkhead failures in 6 to 8 years of clean trade when frequent cleaning is required. Estimating tanker service as one-half each in clean and dirty trade, the author says partial renewal of deck, shell and bottom plating, including some longitudinals, plus complete renewal of internal structure of cargo space would cost $1,000,000 for 500 cargoes between Gulf/North of Hatteras. Figures are given on actual percentage and dollar damage resulting from tanker corrosion. Elements of tankers most subject to corrosion damage are enumerated and illustrated and design remedial measures discussed.

Methods of corrosion control are enumerated and some expericence with the several methods considered. Means of protecting cargo space by treating cargo, cathodic protection, inhibition, dehumidification, deoxidation are reviewed. The advantages of adding extra metal to members subject to greatest corrosion losses are explained and dollar savings given. 6574

8.9.5, 1.2.2, 5.8.2, 4.4.6

Symposium on Control of Internal Corrosion of Tankers. Part 2. Inhibitors in Cargo. J. V. C. Malcolmson, W. S. Quimby, Gwendolyn D. Pingrey, and J. C. D. Oosterhout. *Corrosion*, **9**, No. 11, 395-400 (1953) Nov.; *Trans. Soc. Naval Architects and Marine Engrs.*, **60**, 382-441 (1952).

Part 2. Inhibitors in Cargo: Magnitude of corrosion losses in tankers is detailed. One typical tanker in coastwise service, after 195 mixed cargoes, or approximately eight years' service, had top 18 feet of all cargo bulkheads renewed at a direct cost of $250,000, an average of $1300 per voyage. Lower bulkheads must be replaced in four years, making total corrosion cost $50,000 to $75,000 a year for direct steel replacement costs. Additional costs include $3000 to $8000 a day for lost time while ship is under repair, the difference between normal drydocking and extensive bulkhead renewal being three to four weeks.

Tests on paints, dehumidification, metallic coatings, cathodic protection and water soluble inhibitors show these to be unsatisfactory. An oil soluble inhibitor, on the basis of a 9 months' comparative test, show Monsanto Chemical Company's Santoline C has sufficient merit to warrant additional investigation. 6573

8.9.5

American Bureau of Shipping Explains Its Special Surveys. S. Swan. Am. Bur. Shipping. Paper before Soc. Marine Port Engineers, N. Y. *Marine Eng.*, **58**, No. 7, 60-62 (1953) July.

Requirements of special surveys such as hull and machine surveys held by the Bureau to determine necessary replacement of ship scantlings which have become wasted by corrosion and pitting. Concerning wastage on tankers, clean oils seem to cause the more rapid corrosion in the upper parts of the tanks. Black oils seem to affect the bottom plating to the greatest degree. Engine and auxiliary surveys, reviewing wasted scantlings and wastage of tankers are discussed. Illustrations.—INCO 6564

8.9.5, 6.4.2, 5.4.5, 5.4.8

Anti-Fouling Paints for Aluminum Alloys. *Paint Manuf.*, **23**, (1953) Jan. 5, Jan. 10, Jan. 29.

The development of technique in anti-fouling aluminum ship bottoms is traced. Early attempts to use paints containing copper and mercury compounds failed because both corroded the aluminum. Paints containing organic compounds such as 10-chloro 5:10 dihydrophenarsazine (D. M.) may be used, but compounds developed so far, while not attacking aluminum, have only limited anti-fouling power. In the interim of the development of better organics, an excellent procedure is the use of multiple layers of zinc chromate primer protecting the aluminum and overlaid with, say, cuprous oxide in a vinylite type medium. As a result of work at the Naval Research Laboratory, Washington, anti-fouling paint, specified in 1944, contained copper resinate as a suspension agent and mercurous chloride as anti-fouling agent. The varnish medium was an alkyd resin and a high-viscosity chlorinated rubber to give films with good flexibility. The specification was amended three times. Recently the U. S. Navy has changed over completely to paints based on vinyl resins for coating aluminum PT boat hulls and other craft. The paint system specified consists of a wash primer based on polyvinyl butyral resin and pigmented with zinc tetroxychromate followed by an undercoat comprising a polyvinyl copolymer and resin, with suprous oxide as the sole pigment and poison. As a result of trials by the Admiralty begun in 1949, it has been shown that one coat of etch primer or pretreatment with A.C.P. Deoxidrine followed by one coat each of Admar anti-corrosive (white lead, basic lead sulphate and iron oxide in a linseed stand oil phenol-formaldehyde varnish medium) and one coat of a cuprous oxide plasticized resin varnish type anti-fouling paint allowed only very little corrosion of the aluminum alloy after two years' exposure. The paint coating remained almost intact when a red lead vinylite undercoat applied over an etch primer was substituted for the Admar anti-corrosive paint. Specimens in which the anti-fouling paint containing suprous oxide was applied direct to the aluminum alloy (AW6) showed severe corrosion after three months' immersion, which became increasingly worse up to two and a half years. The most satisfactory coatings to date consist of corrosion inhibiting primers and undercoats of the zinc chromate type followed by an anti-fouling paint containing sufficient copper compounds as the poison to give complete anti-fouling protection for at least six months. Further developments are to be expected as more than one authority has work in hand to produce better anti-fouling paints for this requirement; further organic poisons are being investigated and other types of media are under consideration.—TIME 6581

8.9.5, 3.6.5, 3.2.2

Scale vs. Bare Steel Potential Differences May Explain Unusual Tank Vessel Corrosion. L. M. Mosher. Bethlehem Steel Co. *Corrosion*, **9**, No. 5, (News Section), 1-2 (1953) May.

Unusual type of localized corrosion attack recently made its appearance on relatively new tank vessels in exclusive crude oil service, both coastwise and transoceanic. It is suggested that the observed pitting attack occurs during the clean ballast period only and is accelerated by a galvanic couple between scaled and unscaled steel with the attack concentrated at the small anodic areas of bare steel. —INCO. 6421

8.9.5

Improving the Economy of Sea-Going Tankers by the Use of Steel with a High Resistance to Corrosion and a High Tensile Strength. L. F. Dert. *Schip en Werf*, **20**, 55 (1953) Jan. 30; *J. Brit. Shipbuilding Res. Assoc.*, **8**, No. 7251 (1953) Mar.

Recommends use of steel containing chromium and aluminum (composition not given). Steel is corrosion-resistant and possesses higher tensile strength and elastic limit than conventional shipbuilding steels. Notes on weight savings and resultant reduction in costs are given. After 12 years in service, replacement of cargo tanks amounts to 5% as against 65% in structural steel tanks. —INCO. 6410

8.9.5, 2.2.8, 5.2.2, 4.4.6, 5.8.2

Symposium on Control of Internal Corrosion of Tankers. Part III. Corrosion Control in Practice. A. B. Kurz.

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Part III. Corrosion Control in Practice. Application of a full corrosion control program to a fleet of tankers is described. Aiming at a 50 percent reduction in corrosion losses operators instituted the following:

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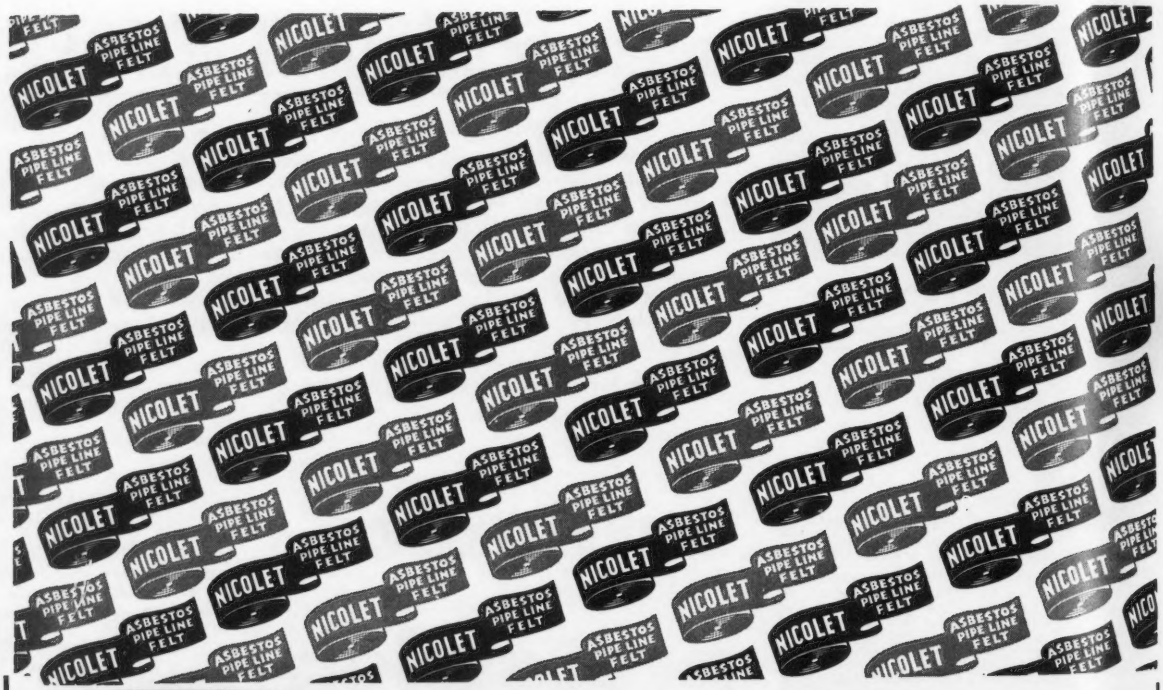

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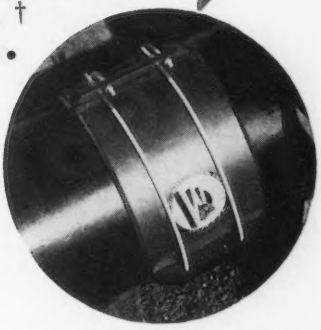

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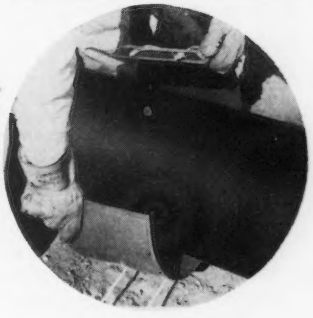

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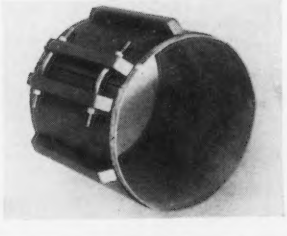

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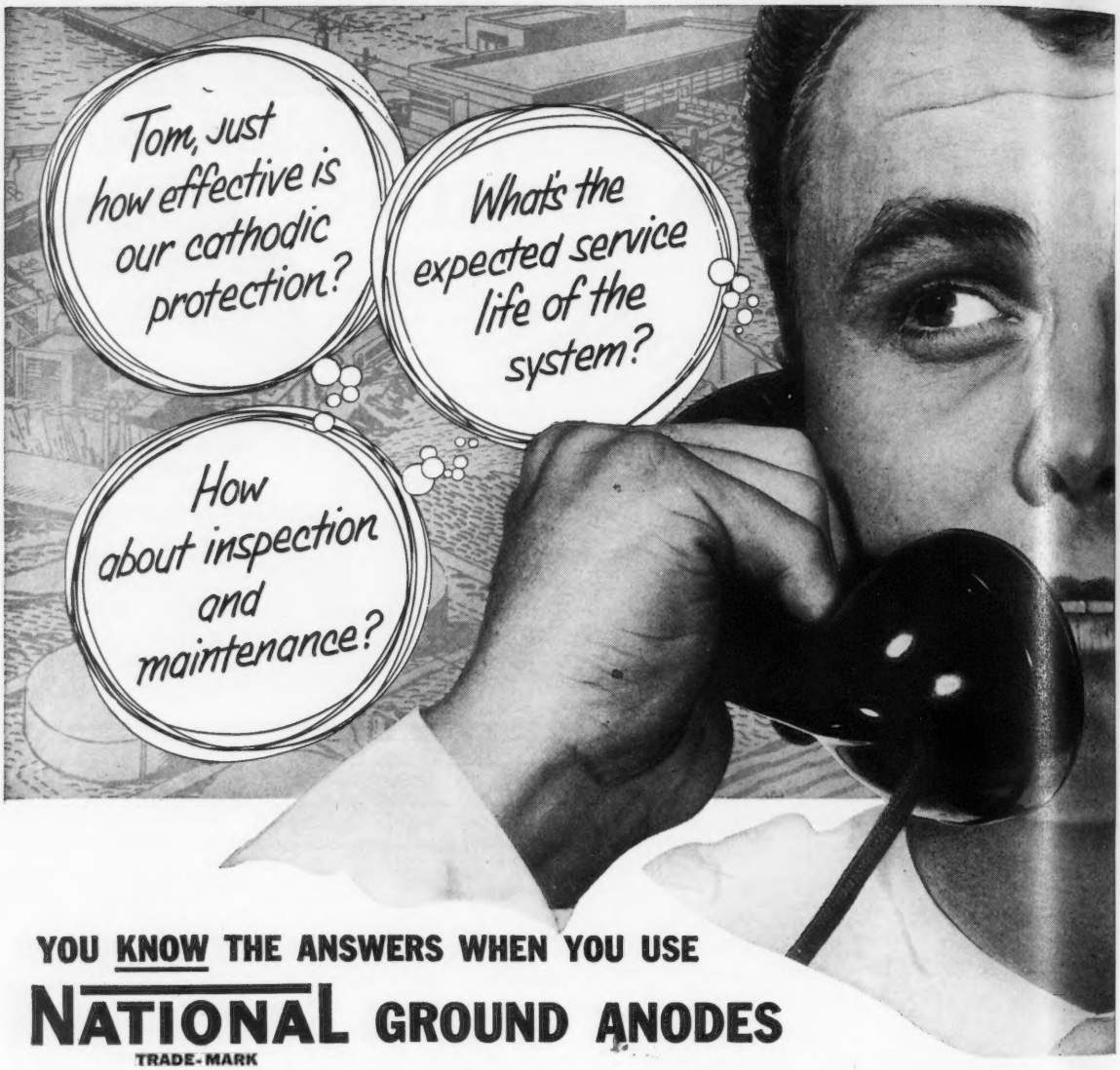
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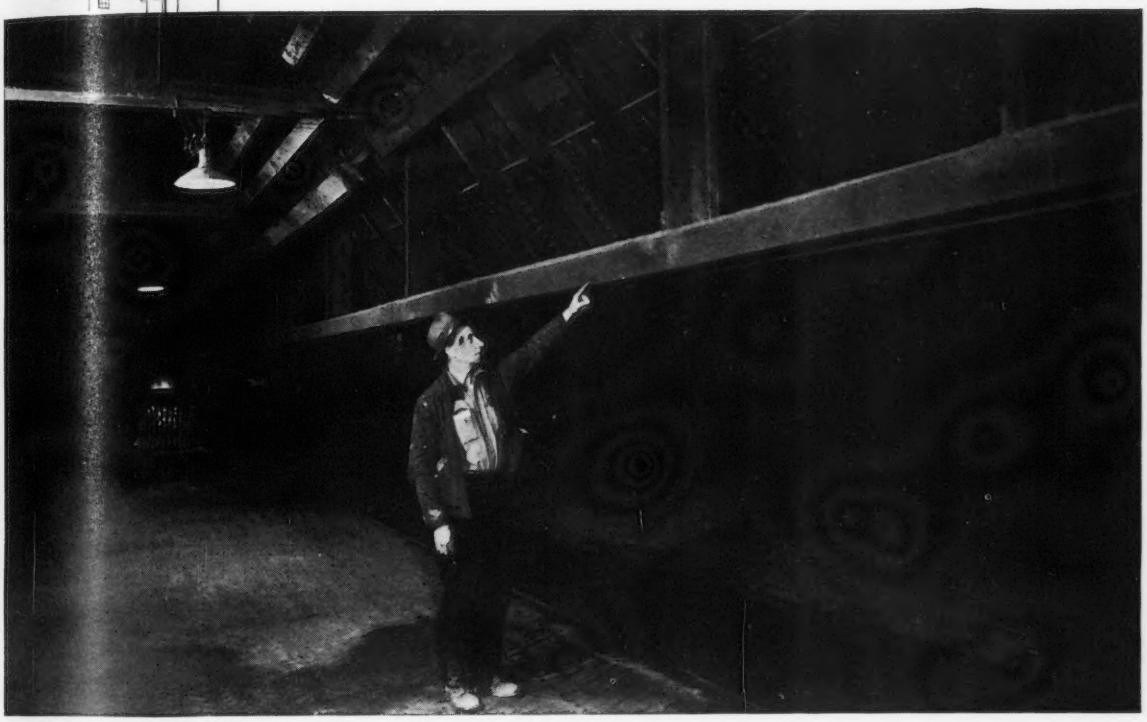

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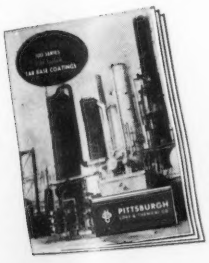

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